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	Engineering and Design MANAGEMENT GUIDELINES FOR LOW-LEVEL RADIOACTIVE WASTE (LLRW) AND MIXED WASTE (MW) SITE REMEDIATION	
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ENGINEERING AND DESIGN

Management Guidelines for Low-Level Radioactive Waste (LLRW) and Mixed Waste (MW) Site Remediation

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ENGINEER MANUAL

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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

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Manual
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Engineering and Design
MANAGEMENT GUIDELINES FOR LOW-LEVEL RADIOACTIVE WASTE (LLRW) AND MIXED WASTE (MW) SITE REMEDIATION

1. Purpose. This engineer manual (EM) contains planning and management guidelines to be used for the cleanup and environmental restoration of sites contaminated by radioactive waste containing low-Level radioactive waste (LLRW) either alone or combined with hazardous/toxic components to make mixed waste (MW). Specifically, the guidelines relate to remedial action concerning essentially uncontrolled LLRW or MW contamination arising from past practices at the sites. The primary purpose of this manual is to describe the regulatory and management responsibilities related to U.S. Army Corps of Engineers (USACE) activities at radioactive (LLRW and MW) waste sites. This manual is not intended to provide detailed technical recommendations or sophisticated scientific procedures. The manual will necessarily incorporate some technical information in order to provide background for the regulatory and management responsibilities. In addition to the USACE, Army and Department of Defense (DoD), these responsibilities are defined/enforced by other Federal agencies including the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Department of Transportation (DOT), and the Occupational Safety and Health Administration (OH-IA).

2. Applicability. The guidelines within this manual are applicable to all USACE elements and major subordinate commands (MSC) having responsibility through governmental interagency agreement or by assignment by HQUSACE for the remediation of sites contaminated by LLRW and MW. These guidelines are applicable to accomplishment of both the Military and Civil Works missions of the USACE. Strictly chemical or biological aspects of sites are not addressed except in passing reference to their component part of mixed waste. Involvement may arise, for example, as support to site owning agencies such as the DOE or as support to the EPA activities associated with non-government-owned site remediation. Such site remediation activities will fall within the purview of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); the Resource Conservation and Recovery Act (RCRA); the Hazardous and Solid Waste Amendments (to RCR4) (HSWA); or the Superfund Amendments and Reauthorization (of CERCLA) Act (SARA). In the event of military (Department of the Army, specifically) responsibility for MW and LLRW sites requiring remediation, this manual applies as directed by HQUSACE. Such involvement will fall under the Defense Environmental Restoration Program (DERP). Oversight responsibilities for managing the Department of Army Radioactive Material Waste Program have been assigned to Headquarters, U.S. Army Industrial Operations Command (IOC), Rock Island, Illinois. In such a role IOC is responsible for disposal of all Department of the Army-generated radioactive material at all currently licensed land burial sites in the

United States, and for maintaining the required records for the Army on the type and quantity of disposed radioactive material.

FOR THE COMMANDER:

OTIS WILLIAMS
Colonel, Corps of Engineers
Chief of Staff

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Chapter 1
Introduction

1-1. Purpose

This engineer manual (EM) contains planning and management guidelines to be used for the cleanup and environmental restoration of sites contaminated by radioactive waste containing low-level radioactive waste (LLRW) either alone or combined with hazardous/toxic components to make mixed waste (MW). Specifically, the guidelines relate to remedial action concerning essentially uncontrolled LLRW or MW contamination arising from past practices at the sites. The primary purpose of this manual is to describe the regulatory and management responsibility related to U.S. Army Corps of Engineers (USACE) activities at LLRW and MW sites. This manual is not intended to provide detailed technical recommendations or sophisticated scientific procedures. The manual will necessarily incorporate some technical information in order to provide background for the regulatory and management responsibilities. In addition to USACE, the Army, and the Department of Defense (DoD), these responsibilities are defined/enforced by other federal agencies including the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Department of Transportation (DOT), and the Occupational Safety and Health Administration (OSHA).

1-2. Applicability

The guidelines within this manual are applicable to all USACE elements and major subordinate commands having responsibility through governmental interagency agreement or by assignment from Headquarters, USACE (HQUSACE) for the remediation of sites contaminated by LLRW and MW. These guidelines are applicable to accomplishment of both the Military and Civil Works missions of USACE. Strictly chemical or biological aspects of sites are not addressed except in passing reference to their component part of mixed waste. Involvement may arise, for example, as support to site-owning agencies such as the DOE or as support to the EPA activities associated with non-government-owned site remediation. Such site remediation activities will fall within the purview of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); the Resource Conservation and Recovery Act (RCRA); the Hazardous and Solid Waste Amendments (to RCRA); or the Superfund Amendments and Reauthorization (of CERCLA) Act (SARA). In the event of military (Department of the Army, specifically) responsibility for MW and LLRW sites requiring remediation, this manual applies as directed by HQUSACE. Such involvement will fall under the Defense Environmental Restoration Program (DERP). Headquarters, U.S. Army Industrial Operations Command (IOC), Rock Island, IL, is responsible for managing the Department of Army and Defense LLRW disposal programs. In such a role, IOC is also responsible for maintaining the related required records on the type and quantity of disposed LLRW.

1-3. References

Related technical references are listed in Appendix A. References to regulations are listed in Appendix C.

1-4. Appendices

Appendix A is the alphabetical listing of references cited in this manual. Appendix B presents a glossary of terms and abbreviations. Acronyms are defined in Appendix B. Appendix C is a bibliography of regulatory documents generally applicable to the regulations and laws pertaining either to LLRW or to hazardous, toxic, and radioactive waste (HTRW); situations involving M W are specified as such only in very recent multi-agency regulations and guidance documents. Appendix D describes Department of the Army (DA) LLRW and MW disposal and remediation policy. Included in Appendix D are recommended forms for USACE project reports on proposed LLRW/MW generation/remediation activities, an outline for disposal plans and reports, and a request for LLRW/MW or generated for disposal.

1-5. USACE Involvement in LLRW and MW

a. Involvement. USACE was deeply involved, by way of its mission in the Manhattan Project of World War II, in the inception of nuclear engineering. Since then, commercial interests and other federal agencies, rather than USACE, have controlled and developed nuclear technology. Discovery and disposal of radioactively contaminated waste have developed into a national problem of sufficient magnitude and complexity that USACE is becoming involved again, this time in the mission of restoring LLRW and MW sites. To enhance the USACE technical capability and support USACE activities, a Center of Expertise (CX) on LLRW and M W was established at the U.S. Army Engineer Division, Missouri River, which is the current USACE CX for hazardous and toxic waste. HQUSACE has developed a unified management plan for HTRW. To support the HTRW CX and the USACE LLRW program, IOC has signed an Interservice Support Agreement (July 199 1) to provide support services in the areas of LLRW collection, packaging, certification, handling, shipping, and disposal.

b. Anticipated origins of missions.

(1) DOE. A number of major LLRW and MW site remediation missions were requested by the DOE. This arises from the Memorandum of Understanding (MOU) between the DOE and USACE (Duffy and Page 1990) in which USACE agreed to support DOE Headquarters, Operations Offices, and subordinate installations in connection with environmental restoration and waste management. By this MOU, elements of USACE continue to be deeply involved in sites such as inactive or decommissioned research reactors, old radioactive waste storage and disposal sites. In addition to the wide range of types of sites, the potential contamination ranges from completely nonradioactive to sites inadvertently involving transuranic and high-level radiation waste.

(2) EPA. USACE and the EPA have in force an Interagency Agreement concerning execution of the CERCLA (Thomas and Dawson 1982). This agreement provides for USCE technical assistance to the EPA during remedial investigation and feasibility study phases particularly to verify reasonableness of design, construction, and operation activities. USACE may also manage design and construction and provide other technical assistance in enforcement-led projects, as well as projects that are funded by individual states or the EPA. CERCLA-mandated efforts can involve nongovernmental agency sites of LLRW and MW contamination.

(3) DERP. USACE will, as the executing agent for DA and DoD, participate as ordered in the DERP and undertake restoration of DoD LLRW- or MW-contarninated formerly used defense sites (FUDS) as well as currently active Army installations. DoD installations involving fabrication, storage, maintenance, application, and use of nuclear weapons, propulsion units, power generators, medical facilities, or other military hardware incorporating radionuclides are addressed by DERP.

1-6. General Policy Considerations

a. Pertinent regulatory agency interfaces.

(1) A historic artifact of the Nation's developed culture and regulatory environment is an effective separation of responsibility between governing agencies based on the nature of dangerous waste material. Radioactive wastes have been the concern, successively, of the Atomic Energy Commission (AEC), the Energy Research and Development Administration (ERDA), the DOE, and the NRC. The DOE was primarily concerned in the past with radioactive wastes generated from defense-related programs of the federal government. Presently, the DOE is deeply committed to high-level waste disposal as well as defense-related material. The NRC was primarily concerned with radioactive wastes arising from commercial industries involved with power generation and medicine. The NRC now must also be concerned with radioactive mining tailings as well as those materials defined in Title 10 of the Code of Federal Regulations. Nonradioactive hazardous/toxic waste (HTW) has been EPA's concern. The EPA is now working with both the NRC and the DOE in developing disposal regulations for MW. The EPA is also working with states in LLRW problem areas. Separation of regulatory responsibilities has not been constant through the evolution of those agencies. Conflicts in defined responsibilities are reflected in various regulations that are located in separate documents but address similar subjects.

(2) Additionally, other levels of government (i.e., Native American tribes, regional compacts, states, counties, and municipalities) have jurisdictions and internal regulations with varying aims and degrees of detail.

(3) USACE, in remediating LLRW sites, must coordinate with the Federal regulatory agencies whose missions include LLRW management. USACE must, in remediating MW sites, coordinate with the Federal regulatory agencies dealing with chemically hazardous materials. USACE must also deal with the other levels of government in order to accomplish its mission in remediation of LLRW- and M W-contaminated sites. Maximum reasonable effort must be devoted by USACE, its personnel, and its contractors to open communication and cooperation with the separate agencies. Conflicts between regulatory responsibilities and satisfaction of requirements of the separate agencies should be recognized by the USACE Project Manager as soon as possible and communication must be established and maintained so as to accomplish USACE missions effectively and efficiently.

b. Public information policy. The agency establishing the scope of work for a particular USACE mission has the ultimate responsibility for public relations, but USACE, under the direction of the lead agency, should endeavor to satisfy the intentions of openness beyond the mandated requirements. Hazardous, toxic, and radioactive wastes are subjects of extreme concern, in some cases fear, to the Nation's population, both general and local. Necessary public information includes appropriate public education pertinent to the missions undertaken, establishment of formal and informal opportunities for public comment, description of the decision-making processes involved in LLRW and M W site remediation, and open disclosure of decisions and activities as they occur. Regulations exist mandating the nature and quantity of public information to be communicated on hazardous and radioactive wastes. These regulations are presented in CERCLA/SARA, RCRA, etc. At CERCLA sites, the primary reference for public involvement and response plans is EPA publication EPA/540/G-88-O02 (1988a).

c. General health and safety policy. LLRW and MW site remediation projects undertaken by USACE and its contractors shall be in full compliance with all federal and local regulations concerning the health and safety of its own onsite personnel, those persons associated with USACE at LLRW and MW remediation project sites, and the general public which may be immediately affected by the USACE work on LLRW and MW remediation sites.

d. General environmental policy. Consistent with its overall organizational concerns, USACE and its contractors shall comply with all federal, state, and local regulations and laws dealing with the preservation of environmental quality, with the mitigation of damage to the environment, and with the remediation of adverse environmental effects arising from its efforts. The subject of concern within this manual is, in itself, remedial action on sites already contaminated by LLRW and MW. The remedial action selected will be consistent with those described in AR 200-1, which include:

(1) Protection of human health and the environment.

(2) Engineering/technical feasibility.

(3) Long-term effectiveness

(4) Life-cycle cost,

(5) Public acceptability.

LLRW and MW contamination arising from past actions by others may preclude restoration to pristine environmental conditions. However, missions undertaken by USACE in this field have as one of their primary goals a reasonable and meaningful improvement in the existing environment.

e. Personnel training and certification. Specialized training courses exist for employees engaged in HTRW projects. This training is available within USACE and other governmental agencies as well as commercial and academic organizations. USACE offices dealing with LLRW and MW site remediation projects shall verify that appropriate training is accomplished by in-house and contract personnel.

1-7. Definitions

The following definitions are considered basic and most pertinent to the remainder of this EM. Additional definitions of terms and definitions of acronyms used in this EM can be found in Appendix B.

a. Activity. A measure of the rate of nuclear disintegrations occurring in a given quantity of material over a unit of time; the standard unit of activity is the Curie (Ci), which is equal to 3.7×10^{10} disintegrations per second (alps). The SL unit is the Becquerel (Bq), equal to 1 dps.

b. Agreement states. Any states with which the Nuclear Regulatory Commission has established an agreement to allow the state to regulate radioactive materials within its boundaries. Nonagreement states will abide by NRC regulations.

c. Alpha radiation. One of the particles emitted in radioactive decay consisting of two protons bound with two neutrons. Travels only a short distance in air.

d. As low as reasonably achievable (ALARA). A policy for maintaining exposures (individual and collective) as low as is reasonable, taking into account social, technical, economic, practical and public policy considerations. ALARA is not a dose limit, but a standard of excellence that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable.

e. Background radiation. Radiation in the environment from naturally occurring radioactive isotopes, cosmic radiation, and fallout from man's activities such as nuclear weapons testing.

f. Beta radiation. One of the particles emitted during radioactive decay, consisting of an electron. Positively charged type is called a positron.

g. Bioassay. Measurement of radioactive material deposited within or excreted from the body. This process includes whole body and organ counting as well as urine, fecal, and other specimen analysis.

h. Combined or co-mingled waste. Waste that contains a radioactive component and a hazardous component, and does not meet the strict definition of a mixed waste.

i. Derived air concentration. The concentration of a radionuclide in air that, if breathed over the period of a work year, would result in the annual limit on intake (ALI) for that radionuclide being reached.

j. Dose. The amount of energy deposited in body tissue due to radiation exposure. Various technical terms, such as 'dose equivalent,' 'effective dose,' 'equivalent,' and 'collective dose,' are used to evaluate the amount of radiation an exposed worker receives.

(1) Dose equivalent, measured in units of Roentgen equivalent man (rem), is used to take into account the difference in tissue damage from different types of ionizing radiation.

Technical definitions for dose terms include the following:

(2) Absorbed dose (D). Energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The units of absorbed dose are the rad and the Gray (Gy). 1 Gray equals 100 rad.

(3) Dose equivalent (H_T): The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and Sievert (Sv). 1 Sv equals 100 rem.

(4) Effective dose equivalent (H_E). The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma W_T H_T$).

(5) Committed dose equivalent ($H_{T,50}$). The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by a person during the 50-year period following the intake.

(6) Committed effective dose equivalent ($H_{E,50}$). The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50} = \Sigma w_T H_{T,50}$).

(7) Total effective dose equivalent (TEDE). The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

(8) Shallow dose equivalent. Applies to the external exposure of the skin or an extremity. It is taken as the dose equivalent at a tissue depth of 0.007 cm averaged over an area of 1 cm^2.

(9) Weighting factor. Factor that represents the proportion of the total stochastic (cancer plus genetic) risk resulting from irradiation to tissue to the total risk when the whole body is irradiated uniformly.

k. Exposure. A measure of the ionization produced in air by X or gamma radiation, equal to the sum of the electrical charges on all ions of one sign produced per unit mass of air. The special unit of exposure is the Roentgen, equal to 2.58 x 10^{-4} coulombs per kilogram.

1. Gamma radiation. Electromagnetic waves emitted from the nucleus of an atom during radioactive decay; highly penetrating, e.g., a substantial fraction penetrates several centimeters of lead.

m. High-level radioactive waste (HLRW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains fission products in concentrations that require permanent isolation.

n. Low-level radioactive waste (LLRW). Radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or uranium and thorium mill tailings.

o. Mixed waste (MW). Waste containing both a radioactive component defined by the Atomic Energy Act (source, by-product or special nuclear material) and a hazardous component defined in the Resources Conservation and Recovery Act (listed or characteristic wastes).

p. Radioactivity. The property of certain naturally unstable isotopes of spontaneously emitting particles or electromagnetic radiation.

q. Transuranic (TRU) waste. Without regard to source or form, waste that is contaminated with alpha-emitting transuranic radionuclides having half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

s. X-radiation; X-ray. Electromagnetic waves identical to gamma radiation, but originating from the orbital electrons and usually having slightly longer wavelengths.

Chapter 2
Description of Radioactive Waste Sites

2-1. Introduction

In the following paragraphs the activities or types of facilities that result in the production of radioactive materials that may be encountered in site remediations are summarized, along with the types of materials produced and their characteristics.

2-2. Hazards from Radioactivity

a. Radiation hazard. Radiation is hazardous because it ionizes atoms and molecules during its passage through biological cells (particularly alpha particles). This means that electrical charges and molecular structures are changed. Resultant changes in the chemicals in which the electrical balance and molecules have been disrupted cause the cell functions to be disrupted. Large doses of ionizing radiation may cause sufficient cell damage to interfere with critical bodily functions or cause permanent changes in genetically inheritable cell structures. LLRW or MW site remediation can expose the unprotected worker to radioactive hazards in the form of sources external to the body or by inadvertent intake of radionuclides (e. g., alpha sources).

b. Nature of radiation types. Many types of radiation comprise radioactivity. The types, as well as the intensities, of radiation determine safety procedures, shielding, and remediation methods. Shielding and other protection methods are technical application subjects which are highly dependent on the physical and chemical nature of the LLRW and MW and on the site conditions. A health physicist knowledgeable in details of the site and materials present will establish the necessary types and amounts of shielding and work practices protecting against radiation hazards.

(1) Alpha radiation is subatomic particles that carry a double positive electric charge and that are identical to the nucleus of a helium atom, consisting of two protons and two neutrons. Alpha radiation has a shorter range and lower penetrating power than other forms of radiation. Alpha radiation can be stopped by the equivalent of a sheet of paper or the normal layer of dead skin cells. Alpha radiation is most hazardous when its source is inside the body after being inhaled or ingested because of its high ionization capability (high mass and electrical charge).

(2) Beta radiation is subatomic particles that can carry either a positive (positron) or negative (beta particle) electrical charge and are comparable in mass to an electron. Low energy beta particles can be stopped by the equivalent of aluminum foil or a few centimeters of air. More energetic beta particles (e.g., from Sr-90) penetrate deeper. Beta radiation is best shielded with hydrogen-bearing compounds to reduce beta-conversion-generated gamma radiation. Beta radiators are hazardous when they are on the skin, in the eyes, or inside the body.

(3) Gamma radiation and X-rays are electromagnetic waves like light or radio waves. This radiation has very high energy and very short wavelengths. Gamma and X radiation penetrates all material to some degree depending on the radiation intensity, the density of the material, and the thickness of the material. Gamma and X radiation is attenuated most by atomically dense materials such as lead. Dense materials (e. g., lead) used as attenuators need not be as thick to be effective as do less dense materials such as concrete. Because gamma and X radiation penetrates matter so effectively, it is a hazard to the entire body regardless of whether its source is internal or external.

(4) Neutron radiation is the emission of subatomic particles like alpha and beta radiation, though it possesses no electrical charge and is one quarter the mass of an alpha and much more massive than a beta particle. Penetrating power (and the power to do biological harm) is dependent on the speed of the neutron particle. Slow neutrons have low energy; faster neutrons have higher energy and can penetrate farther through shielding. Low to medium energy neutron radiation can be stopped completely by materials such as ordinary concrete. Materials consisting of hydrogen compounds (e. g., water, paraffin, etc.) and others (e. g., boron) are particularly effective in shielding from neutron radiation. Neutron radiation can also be absorbed by otherwise stable nuclei, thus making them radioisotopes.

c. Mitigation of radiation hazards. Individuals may reduce the hazards of radiation in three ways. Time of exposure to the radiation should be kept to a minimum because the effects of ionizing radiation accumulate during exposure. Distance from the radioactive material should be kept as large as reasonably possible because radiation is a quantifiable phenomenon and as a given quantity radiates from its source through a volume, its intensity is diminished by spreading. Shielding materials such as lead, concrete, or water will reduce radiation exposures.

d. External radiation.

(1) External radiation may originate from a radioactive material sealed or otherwise contained inside a closed item. External radiation occurs when the body is exposed to an ionizing radiation source externally and the radiation penetrates into tissues. The actual radioactive material is not exposed for possible direct ingestion.

(2) Time minimization, distance maximization, and shielding protect the worker from external radiation.

(3) Film badges and dosimeters record the amount of accumulated radiation exposure the individual has received. Instrumentation can measure the amount and intensity of external radiation present at a location.

e. Surface radioactive contamination.

(1) Surface radiation contamination occurs when radioactive material is deposited on or induced into surfaces of objects, personnel, or structures. Surface contamintion generally occurs when radioactive materials are mechanically deposited, deposited after being water- or airborne, or when neutron radiation activates stable elements into radioisotopes. Surface contamination continues to be an external hazard until the contaminant is taken into the mouth or lungs, or is absorbed through the skin or open wounds; then, it becomes an internal radiation hazard to the individual ingesting the material. Neutron-activated surface contamination is generally fixed onto the surface and less likely to be ingested or inhaled. Deposited surface contamination is usually spreadable or removable and presents the hazard of being ingested or inhaled.

(2) Surface contamination may originate by leakage from a sealed container holding radioactive material, by spilling radioactive material from a container, or by the presence of radioactive material that was never contained. Fixed contamination is radioactive material that tightly adheres to a surface or comprises the surface itself. The hazard from true fixed surface contamination is entirely from external radiation. Removable surface contamination is readily accessible and can be transferred to the skin, to clothing, to tools, etc. Individuals and equipment can move such surface contaminants into formerly uncontaminated zones. Fixed surface contamination can be changed into removable, transportable contamination by disrupting its structure, breaking it up, burning it, digging it up, etc.

(3) Protective clothing can protect the individual from transportable radioactive contaminants. Hand and facial coverings are very important in preventing surface radiation hazards from being accidentally ingested (and becoming the more serious internal hazard) or carried out of the controlled work area. Clothing that has surface contaminants on it is removed before the worker leaves the contaminated area. Hand and face coverings, tools, or work items can be placed in sealed containers or bags if their surfaces may have been contaminated. walls, floors, large equipment, and workers' bodies can be washed thoroughly to remove surface contaminants.

f. Airborne radioactive contamination. Airborne contamination arises as particulate in the air which are radioactive. Certain gaseous radioisotopes such as iodine and radon could be present at M W sites, but the most frequent occurrences will be particulate-borne. Filtered or self-contained breathing apparatus may be necessary in the presence of airborne contamination to prevent it from becoming an internal hazard. Ventilation of confined areas is a necessity to protect against airborne contamination because the chances of concentration of the contaminant are greater. Typical dust control measures will be effective in reducing the hazard of airborne radioactive particulate.

g. Waterborne radioactive contamination. Radioactive particles may be suspended in water; radioisotopes may be dissolved in water. To workers at an HTRW remediation site, waterborne contamination will be a relatively minor external hazard. Waterborne radioactive materials, however, are the most pervasive contamination pathways to the general populace and the environment. Much of HTRW site remedial investigative and cleanup work intended to prevent offsite migration will deal with waterborne radioactive contamination.

2-3. Low-Level Radioactive Waste (LLRW)

a. Low-level radioactive waste definition. LLRW is defined as all radioactive waste except high-level waste and uranium or thorium mill tailings. This definition was erected for purposes of determining methods of disposal of LLRW and high-level radioactive wastes. Most radioactive waste that USACE may deal with is LLRW. LLRW should not be construed to present low hazards. The hazards of radioactive wastes are determined by the type and quantity of radiation emitted.

b. Low-level radioactive waste classification. For disposal of LLRW at near-surface disposal sites, a classification system, based on the longevity and the radiation emitted, has been developed to segregate wastes by hazard. Two considerations are taken into account when classifying LLRW: the concentration of long-lived and the shorter-lived radionuclides. Table 2-1 lists the concentrations of radionuclides used by the NRC to define LLRW. Certain requirements must be met for all classes of LLRW, and are intended to facilitate handling and provide protection to site personnel, the nearby public, and potential intruders into the disposal facility. LLRW is then classified as to the degree of rigor of the required disposal method.

c. Waste form characteristics. The acceptable physical characteristics of LLRW and the containers it is disposed in are determined by the license conditions of the disposal site. For near-surface disposal at compact state disposal facilities, the following characteristics are usually required. For LLRW to be disposed of at Envirocare or other facilities, the acceptable characteristics are listed in the site license. Exemptions may be applied for and are granted if there is no increase in the hazards or risk to the public and environment.

(1) Waste may not be packaged in cardboard or fiberboard boxes.

(2) Liquid LLRW must be solidified or packaged in sufficient absorbent material. Solid LLRW containing liquid shall contain as little free noncorrosive liquid as possible, not to exceed 1 percent by volume.

(3) LLRW must not be capable of detonation, explosion, or any other violent decomposition under ordinary disposal unit conditions.

(4) LLRW shall not contain or generate quantities of toxic fumes or gases during handling, transport, or disposal.

(5) LLRW must not be pyrophoric; waste containing pyrophoric materials shall be treated to be nonflammable.

(6) Gaseous LLRW must be packaged at less than 1.5 atmospheres pressure at 20 “C and each such container will not contain more than 100 Ci total.

(7) LLRW containing hazardous, biologic or pathogenic or infectious material will be treated to reduce the potential hazard from nonradiological materials.

(8) LLRW will possess structural stability to avoid degrading the containment and the site. It will generally maintain its physical dimensions and form under the expected disposal conditions. Conditions to consider in assessing structural stability include weight of overburden, presence of moisture, microbial activity, radiation effects, and chemical changes. The waste form itself may provide structural stability before or after processing; or the waste may be placed in structurally stable containers or structures for disposal. Generally, only those stabilization media that have been evaluated according to the stability guidance requirements of the NRC’s Low-Level Licensing Branch, Technical Position on Waste Form, are considered acceptable media. Liquid LLRW must be converted to a form containing as little free-standing and noncorrosive liquid as reasonably achievable. The volumetric content of the LLRW part of liquid or solid waste will not exceed 1 percent of a single container or 0.5 percent of the volume of waste processed to a stable form. Void spaces within the waste and between the waste and its package will be reduced as much as reasonably possible.

d. Class A LLRW. Class A LLRW is waste that does not contain sufficient amounts of radionuclides to be of concern with respect to migration, long-term active site maintenance, and potential exposure to intruders. Class A LLRW tends to be stable. Class A LLRW is usually segregated from other waste classes at the disposal site. Class A LLRW must meet the minimum handling characteristics required and described above. Class A LLRW has concentrations less than Column 1, and less than Column 4 of Table 2-1.

e. Class B LLRW. Class B LLRW must meet more rigorous standards for stability than Class A. Class B LLW is more highly radioactive than Class A. Class B LLRW has concentrations greater than Column 1 and less than Column 2 of Table 2-1.

f. Class C LLRW. Class C LLRW must meet the most rigorous standards on waste form stability and additional measures at the disposal facility to protect against inadvertent intrusion. Class C LLRW has concentrations greater than Column 2 and less than Column 3, and less than Column 5 of Table 2-1.

g. Greater than Class C LLRW. Waste classified as greater than Class C is not suitable for near-surface disposal. Greater than Class C LLRW has concentrations greater than Column 5 of Table 2-1.

h. Radionuclide concentrations. Concentrations may be measured directly or calculated if there is reasonable assurance of correlation to direct measurements. Indirect methods of concentration determination include inference of one nuclide concentration from that of another which

Table 2-1
Radioactive Constituents of LLRW

Concentration Nuclide	Column 1 Ci/m^3	Column 2 Ci/m^3	Column 3 Ci/m^3	Column 4 Ci/m^3	Column 5 Ci/m^3
C-14				0.8	8
C-14 activated metal				8	80
Ni-59 activated metal				22	220
Nb-94 activated metal				0.02	0.2
Tc-99				0.3	3
I-129				0.008	008
TRU with half-life > 5 years				10 nCi/gm	100 nCi/gm
Pu-241				350 nCi/gm	3500 nCi/gm
Cm-242				2,000 nCi/gm	20,000 nCi/gm
All half-lives < 5 years	700				
H-3	40				
Co-60	700				
Ni-63	3.5	70	700		
Ni-63 activated metal	35	700	7000		
Sr-90	0.04	150	7000		
Cs-137	1	44	4600		

is directly measured, and material inventory records. Concentrations may be averaged by weight or by volume. Classification of mixtures of radionuclides is accomplished by comparing the sum of the fractional proportion of each represented radionuclide to a value of 1.0.

2-4. Mixed Waste (MW)

a. Mixed waste definition. A mixed waste may be a listed and/or characteristic waste that is mixed with an NRC-regulated radioactive material. The radioactive components of mixed waste regulated by the NRC or the agreement state are source, by-product, or special nuclear material, and the hazardous component of mixed waste is regulated by the EPA or the RCRA authorized state. A hazardous waste is defined in 40 CFR 261 as a solid waste which exhibits a hazardous characteristic, is “listed” in the regulations, or is a mixture of hazardous and solid wastes.

b. Enhancements to the basic definition. Radioactive materials that are not source, by-product, or special nuclear materials are not regulated by the NRC, but may be regulated by agreement states, depending on state laws. Hazardous wastes that are not RCRA listed or characteristic hazardous wastes may be regulated by the state as a hazardous waste under state hazardous waste management laws. The state does not need to be RCRA-authorized to establish this authority.

c. Mixed, combined, and co-mingled waste. When non-NRC regulated radioactive materials are mixed with RCRA hazardous wastes, or with state-listed hazardous wastes, or when NRC-regulated radioactive materials are mixed with state-listed hazardous wastes, the waste is considered combined waste, which is sometimes called co-mingled waste. The distinction between mixed and combined or co-mingled waste is important due to disposal options. There are a number of disposal options for combined or co-mingled waste, but only a few options for mixed waste.

2-5. Sources and Characteristics of Radioactive Materials, LLRW, and MW

a. Nuclear weapons facilities.

(1) Facility operation description. The nuclear weapons facilities considered here are those where inspection, storage, and maintenance of nuclear weapons are conducted. TRU materials and wastes are present but are not considered herein. Both LLRW and MW are present as by-products of the processes and operations in the facilities. The weapons are disassembled, inspected, repaired, reassembled, and stored until shipped from the facility.

(2) Types of radiation expected. Examples of radionuclides present in nuclear weapons are uranium-233

and -235, plutonium-239 and -241, americium-241, and hydrogen-3. Depleted uranium is also used in testing and training for weapons maintenance. These radionuclides emit alpha, beta, gamma, and X-radiation.

(3) Types of sources present. The radioactive material can be considered a sealed source when a weapon is assembled. During inspection and maintenance, the radioactive material is an unsealed source.

(4) Radioactive contamination potential. There is no potential for radioactive contamination when a weapon is assembled unless it is subjected to severe physical damage or is damaged by fire. When a weapon is disassembled, there is a slight potential for contamination. This potential increases if the radioactive material is damaged in any way during inspection/maintenance activities.

(5) Radioactive waste generated. Very small volumes of slightly contaminated solid waste can be generated during inspection/maintenance activities. No significant amount of liquid radioactive waste is generated.

(6) Potentially contaminated areas. Areas of potential contamination include disassembly, inspection, maintenance, and reassembly areas; radioactive waste-handling and packaging areas; and decontamination facilities. Sinks, drains, trash receptacles, and formerly used radioactive waste disposal cells are particularly probable contaminated areas.

b. Research laboratories,

(1) Facility operation description. Depending on its mission, a research laboratory may be involved in a wide variety of activities including the analysis of materials activated by neutron radiation, the effects of radiation exposure on animals, and the use of radioactive tracers in chemistry experiments. Various radionuclides may be used in a typical laboratory environment or may be used in closed, shielded cells to protect personnel from radioactive hazards. A reactor or accelerator may also be used at the facility.

(2) Types of radiation expected. Depending on the facility mission, a number of different radionuclides may be used, and alpha, beta, X, gamma, or neutron radiation can be expected to occur.

(3) Types of sources present. Sealed, partially sealed, and unsealed sources can be expected to be used.

(4) Radioactive contamination potential. There is a high potential for contamination in any area of a laboratory where unsealed sources are used in experiments and studies.

(5) Radioactive waste generated. Moderate to large volumes of solid radioactive waste can be expected. Small to moderate volumes of liquid radioactive waste can also be generated. Research labs characteristically produce larger quantities of MW compared to LLRW.

(6) Potentially contaminated areas. Areas of potential contamination include:

(a) Laboratory areas (bench tops, fume hoods, glassware, centrifuges, scintillation counters, hot cells, and refrigerators used for radioactive material storage).

(b) Animal cage areas.

(c) Solid radioactive waste-handling and packaging areas.

(d) Liquid radioactive waste system (tanks, pumps, valves, piping).

(e) Ventilation system (ducting, filters, filter housings).

c. Medical facilities.

(1) Facility operation description. Medical facilities perform a variety of diagnostic and therapeutic procedures using radioactive materials and radiation-producing machines. For diagnostic procedures, radioactive material may be injected into a patient in liquid form or taken orally. Radiation-producing machines such as X-ray units and computerized tomography scanners may be used. For therapeutic procedures, radioactive material may be injected into a patient in liquid form, taken orally, or implanted in solid form. These implanted sources may remain in the patient or can be removed later. Accelerators and highly radioactive cobalt-60 source capsules are also used for radiation therapy.

(2) Types of radiation expected. Beta, X, or gamma sources could occur.

(3) Types of sources present. Sealed, partially sealed, and unsealed sources can be expected to be used.

(4) Radioactive contamination potential. There is a high potential for contamination where unsealed sources are used for diagnosis or therapy. Most unsealed radionuclides used in medicine have short half-lives and, therefore, may not present major decontamination problems for decommissioning. There is a minimum potential for contamination when sources are implanted if the sources are mishandled. There is a slight potential for contamination from sealed sources such as high-radioactivity cobalt-60 sources which are used in radiation therapy units. Contamination may occur from activation products created by high-energy accelerators (> 10 million electron volts) used in research-oriented medical facilities.

(5) Radioactive waste generated. Small to moderate volumes of solid radioactive waste can be expected. Small to moderate volumes of liquid radioactive waste will be generated.

(6) Potentially contaminated areas. Areas of potential contamination may include the following:

(a) Radiopharmacies which are producing, storing, or dispensing radioactive drugs.

(b) Laboratories where liquid sources are prepared for use.

(c) Operating rooms where sources are implanted.

(d) Patients' rooms and examination rooms where patients who have been administered radioactive materials are located.

(e) Nuclear medicine hot labs.

(f) Solid radioactive waste-handling, packaging, and storage areas.

(g) Liquid radioactive waste system (tanks, pumps, valves, piping).

(h) Areas where liquid radioactive sources are stored prior to preparation for administration.

d. Pool reactors and neutron radiography reactors.

(1) These reactors are atmospheric-pressure, water-cooled assemblies generally used to produce long-term, steady-state fluxes of thermal neutron radiation. Some reactors can also produce a high flux of thermal neutron radiation for a very short period of time. The neutron radiation is made available for use outside the reactor by beam ports which penetrate the reactor structure. Items to be irradiated are placed in front of the beam ports.

(2) Primarily gamma and neutron radiation are expected from the reactor. Beta and gamma radiation are expected from the irradiated test items, reactor structures, or impurities in the cooling water.

(3) The reactor fuel elements can be considered a sealed source because the uranium fuel and fission products are contained in cladding. Impurities in the cooling water which become activated can be considered an unsealed source. Any radioactive material resulting from neutron activation of test items or reactor structures could be classified as sealed or unsealed sources based upon the types of materials being activated. Sealed and partially sealed sources will be used for instrument checks and calibrations.

(4) The potential for contamination in a pool-reactor facility can be characterized as moderate. The radioactive material in the cooling water, which results from neutron activation of impurities, is earned through the cooling system and deposited in pipes, valves, pumps, and other system components. When these components are opened for maintenance or repair, or if leaks occur, contamination is likely. The inventory for the coolant radioactive material will be increased if the fuel cladding leaks or is damaged in some manner, releasing fission products into the cooling water. If neutron activation of test items or the structures surrounding a reactor occurs, the radioactive material will be fixed and will act as a source only when the material is dislodged.

(5) Moderate volumes of solid and liquid radioactive wastes will be produced at this type of facility.

(6) Areas and other sources of potential contamination include:

(a) Area housing the reactor.

(b) Areas housing the reactor auxiliary system.

(c) Test items.

(d) Beam ports and equipment used to handle activated test items.

(e) Maintenance areas.

(f) Solid radioactive waste-handling and packaging areas.

(g) Liquid radioactive waste system (tanks, pumps, valves, piping).

(h) Ventilation system (ducting, filters, filter housings).

(i) Decontamination areas.

e. Power reactors.

(1) Facility operation description. The majority of the power reactors in the United States are pressurized water reactors (PWR'S) or boiling water reactors (BWR'S). Other types of reactors include gas-cooled, liquid metal, and heavy water. The reactor fuel produces large amounts of heat as a result of the fission process. This heat is used to generate steam directly in a BWR or is carried by the coolant in the primary system to the steam generator in a PWR or other indirect-cycle reactors. The heat is transferred through the walls of the tubes in the steam generator to the water in the secondary side of the steam generator. The temperature is sufficiently high to change the secondary water into steam. In most plants, the steam travels to a turbine which drives an electric generator to produce electrical power.

(2) Types of radiation expected. Primarily, gamma and neutron radiation are expected from the reactor. Beta and gamma radiation are expected from the irradiated reactor structures or impurities in the coolant. Alpha, beta, and gamma radiation may arise from the spent fuel rods stored at the facility.

(3) Types of sources present. The fuel rods inside the reactor itself can be considered sealed sources, because the uranium fuel and fission products are contained in cladding. However, cladding failure may result in the release of radioactive fission products to the surrounding coolant. Impurities and corrosion products in the reactor coolant which become activated can be considered an unsealed source. Any radioactive material resulting from neutrons activating reactor structures would be classified as a partially sealed source. Sealed and partially sealed sources will be used for instrument checks and calibrations.

(4) Radioactive contamination potential. The potential for contamination in a power reactor facility is greater than that in other facilities due primarily to repair and maintenance activities. The radioactive material in the reactor coolant. which results from neutron activation of corrosion products and fission products from fuel-cladding failures, is carried through the system and deposited in pipes, valves, pumps, the steam generator, and other components. When these components are opened for maintenance or repair, or if leaks occur, contamination is likely. The radioactive material inventory will be greatly increased if a substantial number of fuel-cladding leaks occur or the fuel is damaged in some manner, releasing fission products into the primary coolant. When neutron activation of the structures surrounding a reactor occurs as the system ages, the radioactive material is fixed and acts as a source when the material is dislodged through corrosion and erosion.

(5) Radioactive waste generated. Great volumes of solid and liquid radioactive waste can be produced at this type of facility.

(6) Potentially contaminated areas. Areas of potential contarnination include:

(a) Area housing the reactor.

(b) Areas housing reactor auxiliary systems.

(c) Maintenance areas.

(d) Equipment decontamination areas.

(e) Personnel decontamination areas.

(f) Protective clothing laundry area.

(g) Respiratory protective equipment decontamination area.

(h) Solid radioactive waste-handling and packaging area.

(i) Liquid radioactive waste-system (tanks, pumps, valves, piping).

(j) Ventilation systems (ducting, filters, filter housings).

f. Accelerator facilities.

(1) Facility operation description.

(a) Particle accelerators are radiation-producing machines used for medical, industrial, and research purposes.

(b) Electron linear accelerators (linacs) are used to produce a primary beam of electron radiation (similar to beta radiation though highly directive and of much greater energy) or a secondary beam of X-radiation (similar to gamma radiation) for use in therapy. The patient is positioned relative to the output beam port of an electron lime and the machine is energized for the time required to produce the amount of radiation desired for the therapy.

(c) Electron limes are used in industrial applications to produce a secondary beam of X-radiation which is a penetrating, electromagnetic radiation. The radiation is used for the radiography of such items as welds, castings, and munitions. Electron linacs are used in research applications to determine the effects of irradiation on various materials under study.

(d) Other types of particle accelerators are used for engineering physics research.

(2) Types of radiation expected. Electrons make up the primary beam of electron limes. If the output energy of electron linacs exceeds about 10 million electron volts, neutrons may be produced. Other types of particle accelerators emit alpha particles or other nuclear particles, resulting in secondary radiations and activation of materials. The activated material normally decays by beta- (positive or negative) and gamma-radiation emission.

(3) Types of sources present. Limes incorporate radioisotopes of various species in their sources and in some of their targets. If the output energy of an electron linac exceeds about 10 million electron volts, neutron radiation may be produced. This neutron radiation and output from other types of particle accelerators may activate areas of the device around the output beam port and the structure surrounding the device. If this occurs in solid objects, the radioactive material is considered a sealed source; activated liquids or gases will usually be in unsealed form and more mobile.

(4) Radioactive contamination potential. There are several different types of particle accelerators. Each type and its specific operation must be reviewed to determine the potential contamination.

(5) Radioactive waste generated. No liquid or solid radioactive waste is expected unless the electron linac exceeds 10 million electron volts, in which case small volumes of solid, liquid, or gaseous waste resulting from neutron activation may be produced. Small volumes of radioactive waste may be generated by other types of particle accelerators.

(6) Potentially contaminated areas. If the output energy of electron limes is less than 10 million electron volts, none of the surrounding structure will be contaminated. Energies greater than 10 million electron volts from electron linacs or other particle accelerators will activate components, targets, and surrounding structures, which may result in contamination from loose or disturbed material, during maintenance of the devices, and during decommissioning of the devices.

g. Radiographic facilities.

(1) Radiographic facilities using electromagnetic radiation.

(a) The primary purpose of radiographic facilities is to nondestructively test items for defects. For example, welds are radiographed to reveal any hidden porosity or cracks, castings, or radiographed to reveal any hidden voids, and munitions are radiographed to check for proper assembly. Electromagnetic radiation penetrates a test item and exposes a sheet of film or array of detectors in the same manner that light exposes film or video systems to produce an image. Radiographic films are processed and checked for defects in the item radiographed. The electromagnetic radiation needed for radiography may be produced by a sealed source of radioactive material such as cobalt-60 or iridium-1 92, or by X-ray machines or election linacs. Sealed radioactive sources must be housed in shielded containers when not in use. The containers may be fixed or portable. X-ray machines require no shielding when not in use because radiation is produced only when a machine is electrically energized. Shielding is required when a machine is energized. X-ray machines may be installed in a fixed configuration or may be portable.

(b) Gamma radiation is expected from sealed radioactive sources. Linacs may be used to generate the radiographic beam and their characteristic radiation and waste potential should be expected.

(c) When radioactive material is used, the sources will be sealed.

(d) There is no potential for contamination from an X-ray machine or from a sealed source unless the source is damaged in a manner which breaches the integrity of the material used to encapsulate the radioactive material, or unless the sealed source leaks for any other reason.

(e) None is expected from most radiographic systerns. However, if linacs are used to generate the radiographic beam, the sources and targets are probable waste sources.

(f) There are none, except in the case of linac-generation radiographic systems.

(2) Radiographic facilities using neutron radiography.

(a) Neutron radiography is used to detect moisture and corrosion in bonded honeycombed structures and to test other materials. The secondary radiations created by the neutrons reacting with the material are detected and displayed on monitors that have the capability of digital and imaging enhancement. Most frequently, sources such as radium-226 or americium-241 can be used as sources of alpha radiation impinging on beryllium. The beryllium is activated by alpha radiation to emit neutrons. The radiography occurs in a shielded and interlocked bay, which is accessible only when the source is withdrawn into a shield.

(b) Neutrons from the source are to be expected. Due to neutron activation, alpha, beta, neutron, and gamma radiation may result from irradiated test items and structural materials.

(c) The source is typically sealed hermetically. Source encapsulation failure may occur, causing the direct release of alpha and neutron radiation. Any radioactive material resulting from activation of test items or structural material can be classified as sealed or unsealed based on the types of material being activated.

(d) The potential for contamination is low for properly used and maintained sources. Abandoned or lost source capsules present a serious hazard. It must be noted that the beryllium used to produce the secondary neutron radiation is a very toxic heavy metal. Neutron activation of test items or the structure surrounding the source of neutrons could result in contamination if the material were dislodged and became loose and spreadable.

(e) Very little waste will be generated that is radioactive so long as proper operational, maintenance, and storage practices are followed. Decommissioning of radiographic equipment will generate the largest portion of LLRW of the entire use cycle. The potential for uncontrolled LLRW or MW is greater in the event of equipment abandonment, fire, or other catastrophic event.

(f) Areas of potential low-level contamination are restricted to the radiography bay and test-material-handling areas.

h. Radioluminous-device storage facilities.

(1) Facility operation description. These facilities store new and used radioluminous devices such as clocks, instruments, gunsights, night-vision testers, exit signs, and radioluminescent airfield lighting systems.

(2) Types of radiation expected. Radioluminescent devices use radioactive sources to energize phosphorescent elements or chemicals. The radioactive materials primarily used to generate luminosity are tritium, promethium-147, krypton-85, and radium-226. Tritium and promethium- 147 emit beta radiation only, krypton-85 emits beta and gamma radiation, and radium-226 emits alpha and gamma radiation. Decay products of radium-226, which are radioactive, will also emit beta radiation. Radon-222 is a gaseous decay product which is an alpha radiator and which poses the risk of inhalation to become an internal source.

(3) Types of sources present. Radioluminous devices may consist of instrument faces with the radiation source painted on or may incorporate vials or capsules of radioluminous materials. Because the devices frequently rely on tritium or radium as primary radiation sources, they have great potential to be effectively unsealed. This is because tritium may be a gaseous radioisotope, and because one of the daughters of the decay of radium is radon, which is a gaseous radioisotope. Guaranteed seals, even of encapsulated radioluminous materials, are difficult to achieve and should not be expected.

(4) Radioactive contamination potential. Radioluminous paint is a probable surface and water contaminant when scraped or dissolved off its substrate. The most serious and difficult contamination arising from radioluminous devices is radon emitted from radium-doped paint. Radon is an alpha-radiator and is readily soluble in water or vulnerable to being inhaled. Once internalized, these sources can cause significant biological damage.

(5) Radioactive waste generated. Damaged equipment components which are painted with radioluminous materials will be LLRW. Maintenance of radioluminous systems will generate contaminated cleanup materials. Radioluminous materials characteristically produce gaseous radioactive contaminants. Tritium and radon are readily soluble in water, are easily spread, and can contaminate biological organisms, soil, and groundwater. The great mobility of radiolurninescent-generated waste makes it difficult to clean up. Fortunately, the low energy levels and the small volumes of the original

sources commonly encountered will lessen the environmental impact.

(6) Potentially contaminated areas. There are none, provided the device containing the radioactive material remains intact. Devices with tritium or radium-226 should be treated as suspect to having leakage because of the gaseous radioisotopes involved.

i. Depleted uranium usage and storage facilities.

(1) Facility operation description. Depleted uranium is used to manufacture various types of munitions. These munitions are stored in various facilities and are used in test and practice firings as well as actual warfare. Depleted uranium has been used as armor in some military vehicles and as counterweights in aircraft. Depleted uranium is also used for shielding radiography and teletherapy sources.

(2) Types of radiation expected. Alpha, beta, and gamma radiation can all be expected. Additionally, the radioactive decay of the uranium will produce a sequence of daughter radioisotopes, each of which generates its own characteristic suite of ionizing radiation.

(3) Types of sources present. The depleted uranium in the stored munitions is encased in aluminum or painted, so this source is considered sealed if the case or paint is intact. After the munitions are fired, the sources would be unsealed because the depleted uranium shatters and is dispersed. Depleted uranium used for shields is usually encased in steel and is considered a sealed source.

(4) Radioactive contamination potential. Airborne dust, machine shavings, cutting lubricants, etc., will arise from the fabrication of components from depleted uranium. Waste disposal areas, water drains, and ventilation ducts will be contaminated by the depleted uranium. Once assembled, there is no potential while the munitions are in storage. After the munitions are fired, there will be contamination of target areas and target materials.

(5) Radioactive waste generated. There is little from storage except for radon-222 (inhalable alpha radiation source) produced as a decay daughter. Large fragments of the depleted uranium dispersed after firing and the contaminated targets may be collected and disposed of as waste. Small fragments and uranium oxide dust are not collected and are generally dispersed around the target site. The volumes and dispersal of this contamination are substantial.

(6) Potentially contaminated areas. Firing ranges and targets are areas of contamination.

j. Maintenance shops repairing components containing magnesium-thorium alloys and depleted uranium.

(1) Facility operation description. Machine shops at Air Force Logistics Command Bases repair aircraft parts consisting of depleted uranium and magnesium-thorium alloys by machining, cutting, drilling, welding, and grinding.

(2) Types of radiation expected. Alpha, beta, gamma, and X-ray from thorium-232 and uranium-238, and radionuclides resulting from their decay are expected.

(3) Types of sources present. Depleted uranium as aircraft counterweights and aircraft components manufactured from magnesium-thorium alloys are considered sealed sources except during repair operations which remove metal.

(4) Radioactive contamination potential. There is no potential while the parts are in service or storage. Contamination results from machining, cutting, drilling, welding, and grinding operations.

(5) Radioactive waste generated. Grindings, filings, grinding oils, and broken parts are disposed of as radioactive waste. During grinding of magnesium-thorium alloys, water is used to prevent fires. This water is collected in the hood sump and the water is filtered prior to release to the environment. Both liquid filters and high-efficiency particulate air filters for the hoods are disposed of as radioactive waste. The waste volume generated is not large enough to require a specific storage facility.

(6) Potentially contaminated area. This is limited to the hoods, exhaust ductwork, and immediate area in which repair operations are conducted.

2-6. Sources and Characteristics of Mixed Waste

a. General.

(1) A mixed waste may be a listed and/or characteristic waste that is mixed with an NRC-regulated radioactive material. The radioactive components of mixed waste regulated by the NRC or the agreement state are source, by-product, or special nuclear material, and the hazardous component of mixed waste is regulated by the

EPA or the RCRA authorized state. A hazardous waste is defined in 40 CFR 261 as a solid waste which exhibits a hazardous characteristic, is "listed" in the regulations, or is a mixture of hazardous and solid wastes.

(2) Radioactive materials that are not source, by-product, or special nuclear materials are not regulated by the NRC, but may be regulated by agreement states, depending on the state laws. Hazardous wastes that are not RCRA listed or characteristic hazardous wastes may be regulated by the state as a hazardous waste under state hazardous waste management laws. The state does not need to be RCRA-authorized to establish this authority. When non-NRC regulated radioactive materials are mixed with RCRA hazardous wastes, or with state-listed hazardous wastes, or when NRC-regulated radioactive materials are mixed with state-listed hazardous wastes, the waste is considered combined waste, which is sometimes called co-mingled waste.

(3) The distinction between mixed and combined or co-mingled waste is important due to disposal options. There are a number of disposal options for combined or co-mingled waste, but only a few options for mixed waste. Several common types of mixed waste are described below. Table 2-2 cross-references types of mixed wastes with sites where each type of mixed waste is commonly found.

b. Organic liquids.

(1) Organic liquids are produced by a large number of LLRW generators, and the particular chemicals which may be components of MW include the full suite of hazardous/toxic chemical industry products. Scintillation fluids, which are used in diagnostic tests and general laboratory counting procedures for environmental and facility monitoring, comprise a large volume of MW. These fluids typically contain toluene and xylene. Note that scintillation 'cocktails' containing tritium and carbon-14 at activities below 0.05 μCi/g, can be disposed of without regard to their radioactivity and so are not considered to be mixed waste. However, these scintillation fluids may still be considered a hazardous waste. Since 1990, a number of manufacturers have marketed nonhazardous liquid scintillation fluids that are biodegradable. These cocktails are not considered mixed wastes, and if the radionuclides are tritium or carbon-14 and are below 0.05 μCi/g, they are not considered radioactive waste and so are landfill disposable.

Table 2-2
Mixed Waste Types and Sources

	Types						
Sources	Scintillation Liquids	Organic Liquids	Heavy Metals	Oils	Metallic Lead	Biological	Other
Mines		x	x		x		
Reactors	x	x	x	x	x		
Fuel Processing Facilities	x	x	x		x		X
Atomic Weapons Mfg.	x	x	x				x
Weapons Maintenance		x	x				x
Uranium/Thorium Mills			x		x		
Labs	x	x	x		x	x	x
Hospitals	X	x			x		x
DoD Maintenance Facilities		x	x	x	x		x
Base Disposal Cells			x		x		
Research Facilities	x	x	x	x	x	x	x
Gas Diffusion Facilities							
DoD Logistics Instruments and Articles Storage Areas			x	x	x		

(2) Organic liquids are also generated by the DOE and commercial industries during the manufacture and maintenance of weapons materials and components, sealed sources, pharmaceuticals, radiopharmaceuticals, and diagnostic tests. DOE, commercial industries, and nuclear power plants use organic chemicals, such as acetone and chlorofluorocarbons for cleaning tools, equipment, and instrumentation. Trash can also be contaminated with organic chemicals. Each MW site must be specifically evaluated as to the nature of potential organic waste components.

c. Metallic lead. Metallic lead may become radioactively contaminated when it is used as a shielded container to store radioactive materials or to shield workers from radiation exposure. This lead may be in the form of foil, sheets, bricks, or containers for storage or shipping. Some states have regulations exempting lead used as shielding from classification as a hazardous waste. In California, for example, lead used as shielding in disposed wastes is considered as a scrap metal. If lead is decontaminated, the cleaning solutions containing dissolved lead and radioactive material may be classified as a mixed, combined, or co-mingled waste. Management of lead as a scrap metal or as a hazardous waste is not covered under this document.

d. Heavy metals. The Army and Air Force use many radionuclides for illumination purposes, and use thorium, which is naturally radioactive, in metallic alloys. Both illuminators and magnesium-thorium (mag-thor) parts often contain heavy metals, that if leachable, constitute mixed, combined or co-mingled waste. Weldingrods containing cadmium, a hazardous heavy metal, are used throughout industry.

e. Oils and lubricants. Waste oils and oily trash, principally from radioactively contaminated machine shops, and when drained from engines that use radioactive wear tracers are considered hazardous under some state regulations. The EPA does not regulate waste oil, in and of itself, as a hazardous waste.

f. Biological materials. Biological materials including carcasses, tissue samples, excreta, and cultures often contain radioactive materials. Though not classified as a hazardous material, there are safety and health considerations, and disposal considerations that must be taken into account for work with radioactive biological materials.

g. Disposal. Several facilities are currently licensed to dispose of MW. Each requires some form of treatment prior to disposal and many are limited to the types of hazardous wastes and radionuclides they can accept. These disposal facilities use shallow land burial, deep well injection, incineration, air effluent release, and recycling to dispose of wastes. The HTRW CX maintains information on available disposal methods. Mixed, combined, or co-mingled waste that cannot be treated and disposed of as ordinary trash, LLRW, or hazardous waste will have to remain in storage until disposal facilities are available to accept it.

Chapter 3
Health and Safety

3-1. General

This chapter provides an introduction to the health and safety requirements unique to LLRW and MW site remediation. HTRW health and safety requirements are described more fully in Engineer Regulation (ER) 385-1-92, "Safety and Occupational Health Document Requirements for Hazardous, Toxic and Radioactive Waste (HTRW)," ER 385-1-80, "Ionizing Radiation Protection, " EM 385-1-80, "Radiation Protection Manual," and EM 385-1-1, "Safety and Health Requirements Manual. "

3-2. Responsibilities

a. USACE. USACE has the primary responsibility for ensuring the health and safety of USACE personnel onsite. US ACE has the responsibility of ensuring that all contractors onsite follow USACE accepted health and safety procedures. USACE and the contractor have the responsibility of ensuring that work onsite does not endanger offsite personnel or the environment. All personnel onsite are responsible for maintaining exposures to radiation as low as is reasonably achievable (ALARA). All personnel onsite are required to read and comply with the Site Safety and Health Plan (SSHP).

b. Other governmental agencies. Many sites are under control of other agencies prior to USACE involvement. Where other agencies have the lead, that agency's safety and health programs and plans will be followed by USACE and contractor personnel until responsibility for site safety has been turned over to USACE.

3-3. Programs and Plans

a. Safety and Health Program (SHP). Contractors shall have a written SHP that addresses all aspects of HTRW worker health and safety.

b. SSHP. For each HTRW site, contractors shall have a written SSHP that addresses all expected hazards, and the methods proposed to mitigate those hazards which may be encountered on the site. The SSHP shall address all items discussed in ER 385-1-92, Appendix B. If portions of the contractor's SHP are referenced in the SSHP, those portions of the SHP shall be attached as appendices to the SSHP.

3-4. Radiation Protection Items Addressed in the SSHP

In addition to addressing the health and safety items for HTW sites, the SSHP must address the following items that are unique to radiation sites. These items shall be integrated with the rest of the SSHP to ensure coordination of all health and safety issues onsite.

a. USACE personnel.

(1) USACE will provide the work plan, scope of work, site safety and health plan, etc. which will be reviewed by qualified health physics personnel who are trained in accordance with ER 385-1-92.

(2) USACE will provide site representatives who are trained according to EM 385-1-80.

b. Contractor personnel.

(1) The contractor will provide a certified health physicist, responsible for the review and implementation of all documents and procedures related to radiation protection.

(2) The contractor will provide a sufficient number of radiation protection technicians (sometimes referred to as HP techs) who are trained as required (meeting health physics personnel requirements) in EM 385-1-80 to perform surveys, monitoring, and safety oversight onsite.

(3) The contractor will provide radiation workers who are trained according to EM 381-1-80, (also known as "authorized users assistants") to perform work in the exclusion zone.

c. Contractor dosimetry responsibility.

(1) The contractor has two options concerning dosimetry:

(a) One alternative is that the contractor will monitor personnel exposures, provide appropriate external dosimetry to all personnel exposed to external sources of radiation gamma or neutron radiation), and provide a method for dose determination for personnel who may become internally contaminated with radioactive materials.

(b) The other alternative is that the contractor will provide measurements and documentation that external or internal contarnination could not result in doses to the individuals that exceed 10 percent of the annual TEDE.

(2) A common method for meeting dosimetry requirements includes providing thermoluminescent dosimeters or film badges to all personnel who enter the exclusion zone, and performing air monitoring in the exclusion zone and documenting that the airborne concentrations of radionuclides are below 10 percent of the derived air concentrations listed in 10 CFR 20, Appendix B.

(3) Should a bioassay program be required, personnel should receive a baseline bioassay prior to entering the exclusion zone, periodic bioassays as determined by a health physicist, and a termination bioassay at the end of the project. Bioassay methods depend on the radionuclide and chemical form of concern and may include fecal sample analysis, urinalysis, organ counting, or whole body counting.

d. USACE dosimetry responsibility. USACE will provide appropriate dosimetry for USACE personnel. Dosimeters will be furnished and analyzed by the U.S. Army Ionizing Radiation Dosimetry Program at Redstone Arsenal in Alabama. Should bioassays be required for USACE personnel, these will be coordinated through the U.S. Army Center for Health Promotion and Preventive Medicine at Aberdeen Proving Ground, MD.

e. Equipment.

(1) The contractor will provide surveying equipment capable of detecting the type and intensities of radiation expected onsite.

(2) The contractor will provide monitoring equipment capable of accurately measuring the activity of the radioactive materials expected onsite to the limits of precision required by the regulators for personnel protection and cleanup of the site.

f. Procedures. The contractor shall provide procedures that ensure that doses to onsite personnel and the general public are kept ALARA. These procedures will include, as appropriate:

(1) Limiting the time individuals are exposed to external radiation.

(2) Maintaining as much distance as reasonably possible between personnel and the sources of external radiation.

(3) Providing shielding, when necessary, to lower exposure to ionizing radiation.

(4) Surveying procedures to stop the spread of contamination from the exclusion zone.

(5) Monitoring procedures to ensure that contamination is not released from the site.

(6) Decontamination procedures to ensure that site worker doses are maintained ALARA and to minimize the amount of contaminated waste generated.

g. Emergency contacts. The emergency contacts listed in the SSHP must include the appropriate NRC region or agreement state contact, the appropriate EPA region or state contact, and the Radiation Protection Officer for the USACE District and Division.

Chapter 4
Outline of Regulatory Agency Oversight of LLRW and MW

4-1. Oversight Agencies

Appendix C of this EM is a listing of major laws and regulations pertinent to LLRW and MW disposal, site remediation, and operational practices. The following paragraphs describe the various agencies propounding those regulations. This chapter is not an exhaustive description or listing of all applicable laws and regulations. Identification of applicable laws and regulations is necessarily a site-specific determination made only after full consultation with Office of Counsel. Table 4-1 describes the roles of major federal agencies in regulating LLRW and MW. Table 4-2 describes the areas of responsibility within the DoD for LLRW and MW.

a. DA.

(1) Table 4-3 describes the areas of responsibility for LLRW and MW within the DA. The U.S. Army Materiel Command is responsible for NRC licensing of radioactive material for the Army. The U.S. Army Safety Office is responsible for safety and health issues involving radioactive materials. The applicable regulation, Army Regulation (AR) 385-11, applies to all DA agencies, commands, and installations that procure, use, store, or dispose of radioactive materials or ionizing-radiation-producing devices. Implementation of AR 385-11 throughout USACE is accomplished through ER 385-1-80, “Ionizing Radiation Protection.”

(2) The U.S. Army has been appointed the executive agent for disposal of Department of Defence (DoD) LLRW. The executive agent is responsible for inventorying and reporting all DoD LLRW. The executive agent also serves as the point of contact for the disposal compacts, and oversees two DoD storage facilities for LLRW that cannot be disposed of due to compact status.

(3) USACE is responsible for remediation of LLRW and MW at FUDS, and, at the discretion of the base commander, for remediation of LLRW and MW on active and base realignment and closure (BRAC)-listed bases. USACE disposal of DoD LLRW is coordinated through the HTRW CX to the executive agent. Tables 4-4 through 4-10 describe technical roles and responsibilities of USACE elements for LLRW and MW projects and submittals.

Table 4-1
Major Federal Agencies’ Roles Pertaining to LLRW and MW

Department of Transportation (DOT)	Environmental Protection Agency (EPA)	Nuclear Regulatory Commission (NRC)	Occupational Safety and Health Administration (OSHA)	Department of Energy (DOE)	Department of Defense (DoD)
DOT regulations apply to all intrastate and interstate shipment of DOT-defined LLRW (>2,000 pCi/gm) and MW.	EPA regulations apply to all MW and LLRW. EPA has CERCLA authority over radioactive waste responses, but DOE and DoD may be authorized to take the lead at their own sites. Under the Federal Facility Compliance Act (FFCA), RCRA-authorized states may be empowered to oversee sites contaminated with MW.	NRC regulations apply to source by-product and special nuclear materials licenses.	OSHA regulations apply to the health and safety of workers on hazardous, toxic, and radioactive sites.	DOE regulations apply to radioactive materials, wastes, and all DOE sites through the Atomic Energy Act as amended.	See Table 4-2 for areas of responsibility within DoD.

Table 4-2
DoD Areas of Responsibility for LLRW and MW

Department of the Army (DA)	Defense Logistics Agency (DLA)	Department of the Navy	Department of the Air Force
U.S. Army assigned to be the DoD executive agent for managing disposal of radioactive waste with the exception of the Navy propulsion program. See Table 4-3 for responsibilities within DA.	Warehousing and distribution for instruments and articles containing radioactive material. DLA does not typically generate MW or LLRW and would be under DA authority only if there was generation of MW and/or LLRW.	DA is executive agent for disposal of Navy MW and/or LLRW. The nuclear propulsion program is not under DA authority.	U.S. Air Force (AF) Radio-Isotope Committee (RIC) has the broad-scope license for radioactive instruments and articles. AF retains approval authority for DA remediations on AF bases.

Table 4-3
DA Areas of Responsibilities for MW and LLRW

Corps of Engineers (USACE)	Army Materiel Command (AMC)	DA Safety Office (DACS-SF)
. Responsible for FUDS remediations including radioactive wastes ● May be assigned remediation of radioactive wastes at BRAC, Installation Restoration Program (IRP) and DOE installations ● May support EPA Superfund program or work for others ● Contract responsible person officer (CRPO) responsible for obtaining NRC license and decontamination and decommissioning alternatives risk assessment/OCE (DARA/OCE) permit ● HTRW CX responsible for review and coordination	. Responsible for NRC licensing of radioactive materials for the Army . IOC is responsible for managing LLRW disposal, coordination, and recordkeeping for DoD	. Responsible for health and safety issues involving radioactive materials for DA . Health and safety authority applies to USACE elements doing work on non-DoD sites ● Authority does not cover contractors working for USACE

b. DOE.

(1) DOE has responsibility for the regulation, operation, maintenance, and restoration of all facilities belonging to itself which contain hazardous and radioactive materials and wastes, whether the facility is operated by DOE or by its contractors. These facilities include the range of wastes incident from weapons manufacturing down through small-scale scientific laboratories. Unique among Federal agencies, the DOE finds itself in both the role of regulator and the regulated party at the same facility.

(2) The DOE is presently responsible for environmental restoration of its facilities contaminated by HTRW generated by past practices. The DOE acknowledges and complies with the regulations of other pertinent Federal, state, and local agencies when dealing with the subjects of HTRW and contaminated site remediation. This is most often accomplished, however, by direction to the various contractors operating DOE facilities.

(3) Additionally, the DOE has a Congressional mandate to establish practices and facilities for the disposal of HLRW. Presently, such facilities are not fully

Table 4-4
Technical Roles and Responsibilities of USACE Elements for LLRW and MW Projects and Submittals, CERCLA or RCRA Site Identification Phase

CERCLA or RCRA Stage	Activity	HTRW Design District	USACE District	USACE Division	HTRW CX
Identification	Site background, planning, and objectives	Execute, approve	Coordinate	Coordinate	Review
Preliminary Assessment (PA)	–Scope of work –Limited SSHP –Background and site history and data collection –Site visit – PA report	Execute, approve	Coordinate	Coordinate	Review
Site Inspection (SI)	–Scope of work –Work plan development (DQOs) SSHP –Sampling and analysis plan (SAP) – Field investigations –Sample analysis and data assessment –Data evaluation and fate and transport analysis –Risk screening analysis – Regulatory analysis – Report	Execute, approve	Coordinate	Coordinate	Review
RCRA Facility Assessment (RFA)	RFA has many similar activities with the CERCLA PA/SI. EPA or RCRA-authorized state performs RFA. USACE roles and responsibilities should match PA/SI if USACE element input required.	Execute, approve	Coordinate	Coordinate	Review

Table 4-5
Technical Roles and Responsibilities of USACE Elements for LLRW and MW Projects and Submittals, CERCLA or RCRA Site Prioritization and Delineation Phase

CERCLA or RCRA Stage	Activity	HTRW Design District	USACE District	USACE Division	MCX	HQ USACE
Hazard Ranking System (HRS) under CERCLA	HRS scoring is done by EPA after the SI.					
National Priorities List (NPL) under CERCLA	EPA uses HRS score to determine if site becomes NPL site. NPL site requires remedial investigations/ feasibility studies (RI/FS) and record of decision (ROD).					
RCRA has no equivalent process to HRS scoring	Possible to have a site with dual regulatory authority. Federal CERCLA group and federal/ state RCRA may both claim authority.	Initiate a Federal Facility Agreement among the State, EPA, NRC, DOE, DA, and customer as necessary.	Coordinate	Review	Review	Approve

Table 4-6
Technical Roles and Responsibilities of USACE Elements for LLRW and MW Projects and Submittals, CERCLA or RCRA Site Investigation and Planning Phase

CE=RCLA or RRA Stage	Activity	HTRW Design District	USACE District	USACE Division	QA Lab	HTRW CX	HQ USACE
Remedial Investigation/ Feasibility Study	–Scope of work –Work plan development –Data quality officers (DQOs) –SSHP –SAP – Regulatory coordination/permits, applicable or relevant and appropriate requirement (A RARs), compliance – Field investigations –Sample analyses, data assessment –Quality assurance/quality control –Baseline risk assessment – Remedial alternatives development and screening –Treatability studies –RI report – Detailed analysis of alternatives –Feasibility study (FS) report –Management	Execute, approve	Coordinate	Coordinate	Review, approve	Review, monitor	Monitor
RCRA Facility Investigation (RFI)/Corrective Measures Study (CMS)	The RFI/CMS share many of the same activities as the RI/FS. USACE elements should match the roles and responsibilities under the CERCLA process.	Execute, approve	Coordinate	Coordinate	Review, approve	Review, monitor	Monitor

Table 4-7
Technical Roles and Responsibilities of USACE Elements for LLRW and MW Projects and Submittals, CERCLA or RCRA Decision Process Phase

CERCLA or RCRA Stage	Activity	HTRW Design District	USACE District	USACE Division	HTRW CX	HQ USACE
Record of Decision (ROD) for NPL Sites	– Preparation of ROD (nonSuperfund)	Execute, Approval	Coordinate	Review	Review	Approve
Statement of Basis	– Regulatory agency selects the remedy and the media cleanup standards	Execute	Coordinate	Review	Review	Approve
Non-NPL sites but still under CERCLA	– Determine if state has removal or remediation authority –Follow national contingency plan if state has no authority	Execute	Coordinate	Review	Review	Approve

operational but at such time as the facilities are construtted and approved there will arise a major LLRW generation as a by-product of HLRW disposal activities under DOE auspices.

(4) The DOE presents its regulations, both internal and pertaining outside its agency, in the form of numbered orders. These are listed, among other locations, in DOE Order 6430. la, "General Design Criteria. " DOE

Table 4-8
Technical Roles and Responsibilities of USACE Elements for LLRW and MW Projects and Submittals, CERCLA or RCRA Site Implementation Phase

CERCLA or RCRA Stage	Activity	HTRW Design District	USACE District	USACE Division	QA Lab	HTRW CX	HQ USACE	Executive Agent
Remedial Design	— Contract procurement — Scope of work, work plan, addnl studies, and investigations –Plans, specs, and design analyses –Health and safety –Chemical data –Geotechnical data	Execute	Coordi- nate	Monitor	Review, approve	Review, monitor		Monitor
Remedial Action	– Review and approve contractor submittals –Work plans –SHP –SAP	Coordinate	Execute	Monitor	?	Review, monitor		Monitor
Corrective Measures Implementation (CMI)	The RCRA process shares many of the CERCLA activities. Roles and responsibilities should be applied accordingly	Execute design	Coordi- nate	Coordi- nate		Review, monitor	Approve	Monitor
CERCLA removal actions may be implemented at any time during the investigation or remediation. The NCP must be followed	—Time critical removal actions do not require prior documentation or a decision document –Non-time critical removals (> 6 mos planning) require a decision document (EE/CA or equivalent)	Execute design	Execute remedial action	Monitor	Review	Review, monitor	Approve	
Engineering Evaluation Cost Estimate (EE/CA)	Required for non-time critical removal actions	Execute document	Execute removal action	Monitor		Review, monitor	Approve	Monitor
RCRA Corrective Actions	Corrective actions authority under Part B permit is with EPA or authorized state. EPA/state are authorized to mandate corrective action in any situation with a significant problem	Coordinate	Execute	Monitor	Review	Review, monitor		Monitor

orders incorporate and augment practices developed by its predecessors: the AEC and the ERDA. DOE orders are in the process of being codified in draft form as 10 CFR 834, 835, et al.

c. NRC.

(1) The NRC has the responsibility for assuring and maintaining public health and safety as they may be affected by commercial nuclear facilities. This mandate includes the licensing and regulation of facilities for the disposal of LLRW generated by commercial agencies.

(2) While the mandate of the NRC is oriented toward commercial LLRW generators, transporters, and disposers, other Federal agencies having responsibility for LLRW generation, transportation, and disposal acknowledge NRC regulation. This blurring of the boundaries between commercial and governmental realms most often arises because of varying degrees of commercially contracted operation of the facilities. USACE will comply with NRC regulations addressing LLRW. USACE will comply with NRC regulations concerning the radioactive components of MW while scrutinizing those

Table 4-9
Technical Roles and Responsibilities of USACE Elements for LLRW and MW Projects and Submittals, CERCLA or RCRA Disposal of LLRW or MW Phase

CERCLA or RCRA Stage	Activity	HTRW Design District	USACE District	USACE Division	HTRW CX	Executive Agent
Disposal	– EA/Compacts for LLRW –Disposal to EnviroCare (MW) –Decontamination control facility (DCF)/ disposal or storage – Coordination with Regulatory Agencies – MCX Coordinates with EA – EA Approval	Coordinate	Execute	Monitor	Review, monitor	Approve

Table 4-10
Technical Roles and Rasponsibilities of USACE Elements for LLRW and MW Projects and Submittals, CERCLA or RCRA Post-Closure Phase

CERCLA or RCRA Stage	Activity	HTRW Design District	USACE District	USACE Division	HTRW CX	HQ USACE
CERCLA Sites (FUDS)	Review every 5 yr until NPL deletion	Coordinate	Execute	Monitor	Review, monitor	Monitor
CERLA Sites (BRAC and IRP)	Installation or major Army command (MACOM)	Coordinate	Execute upon request	Monitor	Review, monitor	Monitor

actions for conflict with EPA regulations on the chemical components.

(3) The NRC provides formal regulatory control of LLRW through 10 CFR 20,[1] "Standards for Protection Against Radiation" and 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Wastes. "

d. EPA. The EPA regulates hazardous and mixed wastes because of requirements within the National Environmental Policy Act (NEPA), the RCRA, the CERCLA, and their amendments. RCRA mandates cleanup of contamination regardless of when waste was disposed of. CERCLA mandates cleanup of abandoned hazardous sites. The RCRA, in 40 CFR, Part 261, Subpart D, lists more than 400 specific substances which must be considered hazardous. Determination of waste as controlled by the RCRA is also based on characteristics and properties of mixtures by specifically stated rules. Determination of the hazardous nature of the waste is the responsibility of the waste generator. In 1986, the Superfund Amendments and Reauthorization Act established a National Priorities List of major sites contaminated by past practices which would be restored under the jurisdiction of CERCLA, as amended.

e. 0SHA. Requirements for the protection of workers engaged in hazardous waste operations are set forth by the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA). OSHA regulations dealing with facets of LLRW and MW site remediation and waste disposal include Chapter 29; Parts 1910 and 1926 of the Code of Federal Regulations (CFR). A unique site-specific safety and health plan is required for all remedial actions which shall address the safety and health hazards of hazardous-waste site operations including those dealing with LLRW and MW. Specific points to be addressed in the required documentation include designation of onsite personnel responsible for safety and health, characterizing onsite hazards training, personal protective equipment, monitoring strategies, medical surveillance, site control, decontamination, standard operating procedures, emergency contingency planning, safety meetings and inspections, and provisions for plan changes.

[1] Codes of Federal Regulations (CFR) may be found in Appendix C.

f. DOT. The DOT regulates the interstate transport of any radioactive and other hazardous material shipments. This mandate is made by Chapter 49 of the Code of Federal Regulations. 10 CFR 71 and 49 CFR 170 through 189 also regulate the transportation of nuclear materials, including LLRW and MW.

g. Interstate compacts.

(1) Table 4-11 describes State Compact Agreement memberships as of June 1994.

(2) LLRW disposal facilities. Table 4-12 describes the stages of development of compacts and individual states towards establishing LLRW disposal capacity.

(3) Responsibilities of host state. Each compact, as a whole, selects the host state for a future LLRW disposal facility. From that point, the host state is responsible for facility development and regulation and establishes its own standards and procedures for licensing and control of the facility and LLRW handling. The host state must satisfy the requirements of the Federal regulatory structure concerning LLRW, but otherwise is free to follow its own approach. Therefore, the LLRW disposal regulations established in compacts are diverse. Varying degrees of public participation in the establishment of host state LLRW regulations have occurred and, to some extent, have resulted in regulatory structures which are more stringent and comprehensive than those of the Federal government.

h. Individual states. States may regulate the management of radioactive waste per delegation from the NRC as NRC agreement states. States may regulate the management of hazardous waste per EPA authorization as RCRA authorized states.

4-2. Roles and Responsibilities of States and Compacts Concerning MW

a. Past actions and present status. Individual states and existing disposal facility operators have undertaken their own actions concerning MW disposal. The commercial operator of the LLRW disposal facility near Hanford, WA, elected not to obtain the state-mandated RCRA disposal permit and ceased to dispose of MW. The state of South Carolina expressly prohibited disposal of MW at the LLRW disposal facility near Barnwell. As of mid-1991, a commercial disposal facility, Envirocare, offers its services in Tooele County, UT, to include MW and other radioactive wastes specified in their charter from the state of Utah. It is the only commercial MW disposal facility known in the United States at this time. There are a number of commercial ventures that recycle, incinerate, or otherwise accept for conversion certain specific types of M W.

b. RCRA impacts on MW disposal. MW is now formally subject to dual regulation under both RCRA and the Atomic Energy Act. That essentially defines the regulators as the EPA and NRC, respectively. RCRA allows the EPA to delegate to a state agency the authority to regulate hazardous waste; the NRC agreement state program allows similar delegation of LLRW responsibilities. The EPA assumed responsibility for enforcing, under RCRA, and CERCLA, the regulations incorporating M W.

(1) Current authorization. A state may be granted responsibility for full regulation of MW by the EPA if it has adopted specific MW legislation. States may have RCRA base authorization but still not be authorized to regulate MW. In those states and territories not having been granted regulatory responsibility for MW or not having RCRA base authorization, the EPA regulates disposition of MW. The status of state responsibilities for MW regulation must be updated prior to each project because of the continual evolution of regulatory responsibilities. This may be done by calling the EPA hotline phone number (1-800-424-9346).

(2) Past practice facilities. RCRA regulations allow application for interim status of hazardous waste disposal facilities already in existence prior to 1980. Special application procedures for MW disposal at existing facilities were established in 1988. A primary requirement for the final RCRA permitting of a facility is corrective attention to any previous releases of hazardous constituents.

(3) Joint guidance. Section 105 of the Federal Facilities Compliance Act of 1992 contains the Mixed Waste Amendment. This section amends RCRA and requires DOE to submit plans and schedules to EPA and to authorized states on how MW would be managed at each DOE site. These plans and schedules should be accounted for by the USACE manager. As of March 1995, the EPA and NRC had not developed joint guidance concerning MW, and, specifically, the remediation of M W past-practice sites. Combined jurisdiction by state agencies, the EPA, and the NRC over M W sites can occur in four ways.

Table 4-11
LLRW Disposal Compact Membership, June 1994 (Low-Level Waste (LLW) Forum 1995)

Compact	Member States and Host Status
Appalachian Compact	Delaware Maryland Pennsylvania--future host state West Virginia
Central Compact	Arkansas Kansas Louisiana Nebraska--future host state Oklahoma
Central Midwest Compact	Illinois--future host state Kentucky
Midwest Compact	Indiana Iowa Minnesota Missouri Ohio--future host state Wisconsin
Northeast Compact	Connecticut--future host state New Jersey--future host state
Northwest Compact	Alaska Hawaii Idaho Montana Oregon Utah Washington--current and future host state Wyoming
Rocky Mountain Compact Northwest Compact accepts Rocky Mountain Compact LLRW as agreed between Compacts	Colorado Nevada New Mexico
Southeast Compact	Alabama Florida Georgia Mississippi North Carolina--future host state South Carolina--current host state Tennessee Virginia
Southwestern Compact	Arizona California--future host state North Dakota South Dakota
Texas Compact Compact agreement awaiting Congressional consent	Maine Texas--future host state Vermont
Unaffiliated States	District of Columbia Massachusetts--future host state Michigan New Hampshire New York--future host state Puerto Rico Rhode Island North Carolina

Table 4-12
Commercial LLRW Disposal Capacity Development Status (LLW Forum 1995)

Compacts/ States	Host	Siting	License	Facility Open
Appalachian	Pennsylvania	Siting process under way	Application early 1997 (est.)	Mid-1999 (est.)
Central	Nebraska	Site selected	Application submitted	Autumn 1999 (est.)
Central Midwest	Illinois	Siting process under way	Application November 1997 (est.)	July 2000 (est.)
Midwest	Ohio	Enabling legislation expected in 1995	Application 4.25 yr after legislation (est.)	7.25 yr after legislation (est.)
Northeast	Connecticut New Jersey	Siting process under way Siting plan under public review	Application 1999 (est.) Application January 1998 (est.)	2002 (est.) July 2000 (est.)
Northwest	Washington	Facility operational since July 1965, license reissued May 1992		
Rocky Mountain		Contract with Northwest and Washington for disposal at Washington facility		
Southeast	South Carolina	Site selected	Issued April 1971	Operational until 1996 (est.)
Southwestern	California	Site selected	Issued September 1993 (under litigation)	Mid-1997 (est.)
Texas	Texas	Site selected	Application submitted	Mid-1997 (est.)
Massachusetts		Siting process under way	Application January/ February 1998 (est.)	2000/2001 (est.)
New York		Siting process under way	Application June 1999 (est.)	November 2001 (est.)
Michigan		Siting process under development		
District of Columbia		Not siting a facility		
New Hampshire		Not planning to site a facility at this time		
Puerto Rico		Not planning to site a facility at this time		
Rhode Island		Not planning to site a facility at this time		

(a) A state radiation protection agency and a state hazardous waste program can act in an NRC-delegated agreement state which is also authorized under RCRA.

(b) A state radiation protection agency in an NRC-delegated state can act with the EPA if the state has no RCRA authorization.

(c) The NRC can act with a state hazardous waste program where the state is authorized under RCRA.

(d) With neither agreement state nor RCRA authorization, the EPA and NRC regulate M W.

(4) The EPA and NRC find no inconsistencies between their separate regulatory frameworks as they concern M W. Dual authorizations are required, however, as are dual permits. The two agencies' regulations concerning MW are implemented on a site-specific basis coordinated between the agencies and the state and controlled by factors such as the regulatory structure of the state, the characteristics of the M W, the relative risks from toxicity versus radioactivity, etc. Potential problems in permitting MW activities are foreseen by the states in the timing of deadlines mandated by the regulations. These same problems will be presented to USACE as it deals with MW site remediation, and, as it stands, will require clarification from both NRC and EPA on the same case-by-case basis as do the states.

Chapter 5
CERCLA and RCRA Investigations

5-1. Background

Sites containing mixed hazardous and low-level radioactive wastes are designated MW sites. Although MW falls within the recognized jurisdictions of both the NRC and the EPA, the latter Federal agency has undertaken the monitoring and enforcement of regulations or has delegated those responsibilities to particular states for regulating activities on those sites. Compliance with NRC regulations at MW sites is enforced through site-specific agreements between the NRC and EPA (and state, if so authorized). Regulation of MW site remediation is carried out under the RCRA and CERCLA. Although CERCLA has a generally wider application to site remediation and restoration, it is concerned with the assessment and cleanup of inactive facilities and abandoned sites. Additionally, by means of the Superfund Amendments and Reauthorization Act, CERCLA provides that Federal entities are subject to the requirements for cleanup, just as are commercial facilities. The initial procedures required by both RCRA and CERCLA have essentially identical goals: to delineate the contaminated site, the nature of the contamination, the extent of the effects on environment and populace, and screening of appropriate and feasible means of remediation. Under CERCLA procedures, these goals are accomplished by "remedial investigations/feasibility studies" (RI/FS). Under RCRA procedures, the complementary efforts are "RCRA facility investigations/corrective measure studies." Abandoned sites which are not included on the NPL may undergo engineering evaluation and cost analysis studies (EE/CA) directed towards possible remediation or removal actions. 40 CFR 300.415 states that any release, regardless of site status on the NPL, may call for use of removal actions, subject to regulatory control of the actions.

5-2. Initial Evaluations

a. Description. These evaluations provide a description of what is known of the site and its problems and are the basis for planning and accomplishing the remedial or facility investigations. As with all investigational work plans and efforts, pursued and collected data quality management will ensure that the type, quantity, and quality of data are highly directed to and meet all objectives of the remediation project. The following subjects will be included in the initial evaluations:

(1) A physical description of the site.

(2) A history of the site usage oriented towards potential contamination.

(3) Known and suspected contamination.

(4) A preliminary conceptual model of contaminant transport on and around the site, pathways, and receptors.

(5) A comparison of potential regulatory controls relevant to the site and its contaminants.

(6) A preliminary assessment of risks to the populace and environment.

(7) A brief summary of potential remedial alternatives.

b. Site location and delineation. The initial site description, in most cases, will have been provided by the requesting and responsible state or Federal agency. The site will have been initially screened to identify, in a general nature, the hazards and evaluate its priority for remediation efforts. Though some of the screening study data will not be of use to engineering problems, the entire body of data must be examined critically and in detail to identify the areas of greatest concern. The officially recognized boundaries of the site must be defined along with pertinent geographic and cultural features such as buildings, excavations, transportation paths, etc.

c. Contaminant source locations. Chemical and radioactive material and waste storage areas must be described. These may include storage buildings, process buildings and other structures, tank farms, lagoons *or* excavations, or refuse dumps of containerized or exposed materials. Because the LLRW constituent of MW can comprise virtually any artificially created or modified objects, great care and intuitive investigation may be required. In addition to waste storage areas or improper disposal areas themselves, the access paths used to gather the waste together must be examined for contamination. Physical egress paths of waste or waste-contaminated intruders must be specifically ruled out by investigation or followed if found. It may be found that the necessary survey boundaries should be expanded to encompass such inadvertent releases. In the opposite sense, it may be found during the preliminary assessment and remedial investigations that subdivisions of an overall, larger site may be more appropriate in terms of priority, remediation methods, and management purposes. USACE should be alert to such modifications to the scale of the overall remediation effort and be prepared to obtain the necessary authorizations from the site owner and the regulatory agency.

d. Contaminant material identification.

(1) LLRW. Low-level radioactive waste can consist of virtually any type or configuration of material used in laboratories, chemical processes, medical, and industrial operations. The LLRW must be verified to not be high-level, that is, it may not be used fuel rods or reprocessing waste, it may not be specially classified because of its high activity, nor may it contain transuranic elements. High-level waste excluded, the sole criterion for LLRW is the presence of radioactivity as defined in NRC regulations. Mundane examples include janitorial supplies or in situ soil contaminated by radionuclides; exotic examples include research laboratory animal carcasses or nuclear medicine diagnostic equipment. The preliminary site assessment survey provided to USACE should (but may not) include historic records as to the general source and nature of materials brought into or generated at the site. That historical record should be verified and expanded as much as possible. Onsite preliminary investigations may include instrumental surveys (Geiger counters, scintillation detectors, etc.) and sampling by wipe procedures on objects, limited sampling of soil and water, and sampling of atmospheric and soil gases for detailed laboratory evaluation. Selected surveys and analyses should serve specific objectives in the investigation but, at this stage of investigation, a more general plan is required because of probable incompleteness of site knowledge. The background radiation levels on and around sites potentially contaminated with LLRW and MW must be determined in this initial evaluation. The measured background levels give data to which localized contaminant levels can be compared. The background levels will be rechecked periodically through all stages of investigation and remediation and contaminant level comparisons made with the most applicable background radiation data.

(2) MW. The additional component of hazardous or toxic chemicals in MW widens the scope of historical and onsite identification surveys and complicates the safety and health precautions necessary but will be accomplished in the same intensive detail as identification of radioactivity at the site. This stage of investigation is early and a large base of site data is unlikely. Data quality management will reflect the need of more data for future target identification and for statistically meaningful risk assessments.

e. Potential transport pathways. Contaminants, both radioactive and toxic, can be transported around or off the defined site by air flow, groundwater flow, surface water flow, air- or waterborne sediment, and biotic movement. Data from the past history of site usage and monitoring will aid in developing reasonable transport pathway concepts. Data may be sparse and unevenly distributed or absent. In the preliminary stages of focusing the remedial investigative effort, it will be necessary to integrate contaminant, hydrodynamic, geohydrologic, geologic, and biologic principles to develop the conceptual contaminant pathways from source to receptor. An important objective of the effort to model potential transport pathways and receptors is to establish strategic locations for sampling in the later stages of investigation.

(1) Airborne transport. Frequent or seasonal high wind conditions must be considered together with ground cover and moisture conditions to establish the potential for contaminant transport. Most often, dust or blowing trash will be the transport medium. Development of the transport model should not ignore the potential for toxic or radioactive vapor or gas releases and appropriate investigations should be made.

(2) Groundwater transport. A primary pathway for migration of both radionuclides and toxic chemicals is by way of the flow of groundwater beneath the site. Detailed geohydrological investigations will be a major part of the effort carried out during the RI/FS process to define the quantities and rate of downward seepage from the surface, through or past the MW, through intervening strata to the water table, and through both aquifers and aquitards. As much information as possible should be gathered during preliminary investigations to characterize groundwater under and around the site. Depending on the site climate, history of usage, MW physical and chemical characteristics, and geohydrological characteristics, leached radionuclides or chemicals may be found to have contaminated strata and groundwater to some degree. That contamination poses a potential immediate risk to the public that must be evaluated as soon as its existence is noted. Also, contaminated groundwater (if discovered) will be a health and safety hazard to onsite investigators which must be accommodated in the health and safety plan.

(3) Surface water transport. At the minimum, meteorological histories and characterizations will be possible in the preliminary stages of investigation. These

data, along with observed water flow paths, allow characterizations of potential pathways by that route, assessment of the resultant risks, and identification of vulnerable receptors.

(4) Biotic transport. In the absence of a prior life form monitoring program at the site, it will be necessary to extrapolate animal and plant population characteristics from short-term observations and regional data. Land animals, birds, and fish, both resident and visiting, may be mobile vectors for chemical and radioactive contaminants, transporting them both externally and internally. Other aquatic animals besides fish are less mobile but may still move with the surface water. Vegetation pathways frequently occur by animal ingestion and subsequent evacuation elsewhere.

(5) Projected life of hazard. Although decomposition occurs, the hazardous component of MW is not characterized by the regulatory framework as having a definite lifetime. The hazardous nature is controlled by the chemical's stability under ambient physical-chemical conditions and by dilution. Radionuclide components of MW, on the other hand, have distinct life-spans unaffected by ambient conditions. These life-spans (described in terms of half-life) result in steadily decreasing concentrations as time passes. "Daughter" radionuclides are produced by this spontaneous decay and must themselves be considered in the waste inventory. Half-lives are a primary basis for LLRW classification and consequent disposal requirements. A typical rule of thumb signifying meaningful radioactivity within decay sequences is 7 to 10 half-lives of the longest-lived daughter product. Analytic definition of the radionuclides present in the MW thus provides the information necessary for the performance-based goals of selected disposal methods, the levels of risk that define the degree of hazard, and the projected life of the hazard.

5-3. Remedial Investigations

a. Basis for investigation approach. The basic reason for undertaking the remedial investigation is to produce data necessary for rational decisions in assessing the level of risk associated with the site and its hazards. That assessment of risk, backed by its database, allows determination of the feasibility of alternative remedial actions. Common practice, encouraged by current EPA (EPA 1987) and other agency guidance, is to perform the remedial investigations in phases. This is intended to optimize the quantity and quality of the data by keeping the investigating effort focused on specific remedial action feasibility.

b. Approach of investigations. In the initial phase of investigation, reliance will be placed on screening level data, subsequently expanded by detailed data from targeted investigative efforts. The basic concept of the approach is to maximize the extent of reliable, useful information obtained for reasonable resource investment and reserve highly concentrated investigative efforts for detailed risk or remedial action feasibility studies. Besides avoiding redundancy of investigative efforts, such a phased approach to investigations also minimizes generation of radioactive and hazardous waste by the act of remedial investigation. Especially in the area of monitor wells and sampling borings, careful phasing and close targeting of the borings only where they are most needed will minimize inadvertent cross-connection of contaminant pathways.

c. General types of investigations.

(1) Source locations. Topographic base maps of the site will be created and kept current which show existing facilities, known contaminant sources, survey locations, and other data as they are generated. The base maps may be subdivided into more detailed parts for large, multi-unit sites. The maps should be of third-order precision with contour intervals of 2 ft (0.6 m). Surface radiation surveys should be conducted in a methodical, well-recorded manner at the field screening level of precision. Methodical, well-recorded walk-over reconnaissance examinations of the site should be conducted to screen for hidden waste. Historical aerial photographs, recent aerial photographs, and aerial examinations may be used to search for old drainage paths, trenches, pits, or other crypto-archeological evidence of possible contaminated areas. Surface-based geophysical reconnaissance may include ground-penetrating radar, magnetometer, or electromagnetic induction surveys to locate shallow buried waste forms.

(2) Structural investigations. Structures on a potentially contaminated site are primary targets of investigation for radioactivity and for bulk waste materials. Interior walls, doorways, floors, workbenches, ventilation system components, plumbing, etc., are the types of surfaces in buildings which may have been accidentally contaminated in the past. Containers such as tanks, pipes, reservoirs, dry wells, and cisterns could act as catchments for contaminated waste materials at old sites. Maintenance areas near buildings such as wash racks, motor pools, etc., also can be areas of concentrated contamination.

(3) Vadose zone and soil investigations.

(a) The specific objective of vadose zone and soil investigations is a detailed characterization of the subsurface above the groundwater or aquifer. Very shallow zones at critical locations near disposal units or drainage structures may be examined by means of excavated test pits. Radiological and chemical analysis samples may be obtained from pits, and lateral variations of near-surface materials may be examined in excellent detail. Borings will be made and samples retrieved from them for analysis and for engineering properties. Typically, analysis samples are obtained from the borings in which groundwater monitor wells are to be placed. This is efficient and provides direct point information on the nature of the subsurface materials and the contaminants at the monitoring location. Specifications for sampling equipment and method of drilling are dependent on the site and engineering considerations. In particular, the method of drilling must preclude cross-contamination and minimize contaminant migration. Aller et al. (1989) present a complete description of current monitoring well practices. Specific studies of contrasting drilling practices between HTRW and radioactively contaminated sites have not been made. Commonly used drilling equipment or supplies used at an LLRW or MW environmental restoration site should, at the minimum, be shown to not increase background levels of radioactivity.

(b) Criteria for sampling frequency are site-dependent and hazard-risk-dependent, i. e., with no reasonable expectation of serious contamination the specification may take the form of a sample taken every several feet or, at a grossly contaminated spot, the subsurface samples may need to be essentially continuous to completely delineate stratification. Lithologic classifications and many properties of recovered samples will be collected from this phase of subsurface investigation. Those physical characterizations will be used to support the engineering portions of remedial actions.

(c) All excavations made for subsurface investigations which are not to be maintained or further developed for monitoring purposes will be backfilled. The backfilling method is to prevent cross-connection between water-bearing zones and to prevent release of subsurface contaminants to the surface. Backfilling methods will be described in the investigation work plan.

(d) Borehole geophysical logging will be performed in selected borings and will include natural gamma, gamma-gamma density, neutron-epithermal neutron water content logs. These and any other geophysical logs, the lithologic logs, and samples will be used to develop vertical profiles of strata and for lateral strata correlations. Surface-based geophysical surveys of the vadose/soil zone include those methods such as electrical resistivity and seismic refraction which can be used for engineering information as well as delineation of water tables and lateral material variations. The screening level surface geophysical surveys performed to locate contaminated areas will also provide data for the near subsurface characterizations.

(4) Groundwater investigation. Groundwater may be in the form of confined or unconfined aquifers. In some special cases, the groundwater of a particular portion of a major MW site may be designated as the operable contaminated unit to be investigated and remediated quite apart from the ground surface above it. Most often, however, the groundwater is incorporated in site actions. The water table (potential piezometric pressure in the case of confined aquifers) configuration, including its sources, sinks, and communication with surface water, will be characterized accounting for seasonal, etc., changes. Monitoring wells will be located strategically to fill gaps in the coverage of prior data. Clusters of wells will be used to investigate individual hydrological horizons, interconnections, and gradients. Monitoring wells satisfy multiple purposes. Water levels and changes indicate seasonal variations in the site hydrology. Water samples are analyzed for natural chemical characteristics (pH, cations, anions, etc.) as well as contamination. Gasses above the water in the wells can be investigated for radon or tritium concentrations. Aquifer testing in the wells will provide transmissivity and storativity data characterizing the aquifer. Aquifer testing may be performed in single wells as so-called slug tests rather than as large-scale pump tests if it is not feasible to treat, store, or dispose of potentially contaminated pumped water. Reinfection of the pumped water back into the aquifer is a possible alternative but must be very carefully thought through because of the potential for degrading the pump test data and for adversely affecting the groundwater regime. Though the investigated volume of aquifer tested by slug methods will be quite small, potentially contaminated water will not be brought to the surface. Properly designed and developed monitoring wells will continue to provide data throughout the latter stages of RI/FS, during actual site restoration, and afterwards can allow monitoring the effectiveness of the actions. Temporary wells or other expedient means of sampling subsurface water may be economical. Temporary wells or expedient access to an aquifer must be controlled to not cross-connect separate aquifers and to be properly backfilled and sealed when decommissioned.

(5) Surface water and sediment investigation. Contaminants may reach surface water bodies and sediments by way of past direct discharges, runoff, outflow of contaminated groundwater, or from upstream sources unrelated to the particular site. Many direct discharge pathways can be discerned from old drainage structures or other facilities found during preliminary and remedial investigations. Runoff from sites on high ground will be controlled by meteorological conditions during the site's history modified by the site topography, geology, vegetative cover, and seasonal climate. In addition to meteorological runoff, sites located on low ground such as flood plains or valleys may experience flooding due to distant storms, snowmelt, or human construction activities. In such a low site, backwater flooding arriving from downstream may also be a possibility to be considered in planning remedial actions. Geology may also assist methodical observations in locating springs or seeps of subsurface water. Stream channel cross sections will be measured at locations appropriate to characterize both the surface hydrology and the specific sampling points. Each point or area determined by deduction and surface inspection will be subject to a detailed program of water and sediment sample recovery and analysis. Direct field measurements of radiation levels and distributions, flow rates, temperature, pH, and electrical conductivity will be performed at each designated water/sediment monitoring point. Sampling and direct field measurements will be continued at the designated points to develop a time record of changes during site restoration. Findings of this set of investigations will influence the planning of aquatic biological investigations.

(6) Air investigation. The objectives are two-fold: to assess personnel exposures during field investigations and to characterize particulate contamination spread by air transport. Historical meteorological data will be compiled from the nearest effective measurement stations. Some sites may be remote from established measurement stations and meteorological stations will need to be created nearby (not directly onsite so as to simplify personnel access to the station). Precipitation, temperature, wind characteristics, barometric pressure, vertical atmospheric variations, weather extremes, air quality, relative humidity, and evaporation rate are the primary measurement items. Direct air monitoring for volatile hazardous compounds and radiation will be required by the health and safety plan for all initial reconnaissances and intrusive activities such as digging and drilling. Air sampling will be done during all intrusive activities such as drilling by using high-volume air samples. The sampling filters will then be analyzed in the laboratory for radioisotopes that the site history and prior measurements indicate may be present. The radiation levels will be compared with background levels obtained at specially designated reference points. Exceedance of the backgrounds by certain proportions will dictate appropriate safety and health precautions and a more detailed and extensive series of samples and analyses.

(7) Biological investigations. Contaminant source location surveys and surface water investigations will influence the planning of biological studies. Observation of data quality objectives will ensure that the biological studies are directed to well-defined species and contaminant targets. Assessment of the risks to the biota, as well as human populations, will be the primary reason for all biological investigations at LLRW and MW remedial sites. These studies will evaluate the nature and extent of contamination in plants and animals, identify members of the ecosystem, identify critical habitats and endangered species, and characterize the ecological relationships of the site with reference to past contamination and the effects of restoration activities. An appropriate number of sampling stations will be established to obtain terrestrial species and sampling stations will also be established for aquatic species. These latter aquatic sampling stations will also be used as surface water and sediment sampling stations. All plant and animal samples collected will be analyzed for radionuclides. Chemical contaminants determined by historical review and laboratory analyses of soil, groundwater, or surface water to be present onsite will be targeted in biological assays.

(8) Cultural resource investigation. Cultural resources include both prehistoric and historic artifacts and sites. A literature search and interviews of descendants and cultural groups will be conducted to provide a basis for characterizing the site cultural resources. A qualified field archeologist will conduct a field survey of the entire MW site prior to any intrusive remedial investigations. Those sites determined by the literature search and personal testimonies will be verified as to location and nature. Additional undescribed sites of cultural relevance will be duly characterized as found. Particular care will be taken in the areas of planned remedial intrusive activities. Discovered cultural resources vulnerable to remedial activities may force relocation of the point of investigation or may require development of a cultural resource data recovery plan (i. e., "harvest" all possible archeological/cultural data to the point of the destruction of the site with regulatory approval). Data from remaining cultural sites will be incorporated into all feasibility studies as impacts on the remedial actions.

5-4. Report of Remedial Investigations

At the completion of remedial investigations, a report will be prepared. This report may be a singular document or may comprise a portion of a more general report of remedial investigation. It will consist of a summary of the characterization of the LLRW or MW, the site, and their effects on the human populace and environment. The conceptual model against which the remedial action alternatives are to be cast will be described; sources of contamination will be fully described; the nature and extent of contaminant ion in soil, air, groundwater, surface water, sediments and life forms will be described; a complete list of pertinent regulations will be provided together with the manner they impact site remedial actions; and risks posed to humans and the environment by undertaking no action or any remedial activities will be presented. The remedial investigation data reported will support the selection (or rejection) of alternative remedial actions to be taken and will provide the engineering data necessary for design and accomplishment of the site restoration.

Chapter 6
CERCLA Feasibility and RCRA Corrective Measures Studies

6-1. Background

Feasibility studies (FS) and corrective measures studies have the common objective of developing a set of alternative remedial actions which are potentially able to be accomplished at the LLRW or MW site and which will mitigate or negate the hazards the waste site poses to the general population and the environment. Because of this commonality, the FS and CMS will be described together. Potentially appropriate remedial plans are developed in two phases: identification and initial engineering conceptualization of potentially valid remedial measures; and first-level screening evaluations of the identified remedial alternatives. These phases of identification and initial feasibility evaluation will be conducted concurrently with the ongoing remedial investigations. The remedial alternatives will be developed using the data and interpretations from those remedial investigations, i.e., the concepts will be in a constant state of change as new data are incorporated and their feasibilities will also be adjusted continually to reflect knowledge of the site as it becomes available.

6-2. Remedial Action Objectives

The objectives of the general body of possible remedial actions will be stated. The purpose of those objectives is to state the goals of environmental-medium-specific ways to protect human health and the environment or the goals of source-specific ways to protect health and environment. Specifically, identified hazards or risks will be mitigated by discrete actions. Pathways of contaminant transport may be severed or redirected, the sources of the contaminants may be stabilized or removed, or other actions may be taken. Contemplated actions will be specifically directed to defined hazards and assessed risks. Contaminants, specifically radioactive waste, will be specified, pathways of transport will be delineated, potential receptors vulnerable to the hazards will be specified, and acceptable contaminant levels will be quantified for each source/pathway/receptor combination. Those acceptable levels will be determined by regulation or by assessed risks.

6-3. General Response Actions

These actions are broad classifications of actions or combinations of actions that will satisfy the objectives of remedial actions as described above. General response actions will be developed for the specific MW site and source conditions. Examples of these general response actions are no action, institutional controls, disposal, extraction, excavation, containment, and treatment. Site and waste characteristics will be identified during investigations and will weigh heavily in developing general response action descriptions.

6-4. Identification of Potential Remedial Technologies

Each general response action identified will have a list of potential remedial technologies developed for itself. Each item on those lists of technologies will address the particular site and waste characteristics as identified in the remedial investigative report. Those technologies for which there are alternative processes will be further described addressing each of those optional processes as they pertain to the subject site. The process option descriptions will be the most basic subdivisions of remedial technology descriptions in the feasibility study. There are many potential technological areas and many possible processes within each technological area. New processes are being developed or are being adapted to new applications; this process development and selection is the point of application of engineering to environmental restoration.

6-5. Evaluations

The characteristics of particular LLRW sites as revealed by the remedial investigations may indicate that certain of the technologies and process options that have been identified as potential are, in fact, not suitable. Each process option of each potential remedial technology that addresses each general response action must be evaluated. This evaluation effort will be ongoing, continuous, and is intended to keep remediation resources and attention concentrated on the best potential remedial actions for the site. Criteria of effectiveness, ability to implement, and cost will be used to evaluate the process options.

6-6. Collation of Remedial Alternatives

Preliminary remedial alternatives will, after having been screened as described above, be assembled on the basis of the specifically targeted environmental media they have in common and the MW sources they have in common. This collation is intended to gather together all the process options and technology types to examine them on a common, site-specific and site-wide basis. Again, as in other stages of the feasibility study process, the objective is to satisfy the requirement to protect humans and the environment while keeping the range of alternatives limited and focussed on the problem at hand. Innovative technologies and processes may be applicable and should be considered, though without either special preference or prejudice. Some technology types will demonstrate only one viable process. Some technologies will have multiple process options that are applicable to the particular site; at this stage of feasibility study it is not necessary to carry along many similar processes so long as documentation allows reconsideration at a later time. The following minimum set of alternative action types will be developed if at all possible:

a. No action. There will be an examination of the "no-action" alternative which is performed on an equal footing and with equally rational methods to all other alternative remedial actions.

b. Containment. One or more alternative actions will be developed that involve containment of the MW with little or no change in its inherent nature.

c. Treatment. One or more alternative actions will be developed that involve changing the inherent nature of the MW in such ways that human health and the environment are no longer threatened by it. Some hazardous toxic components can be treated to make them not hazardous. The radioactive components cannot be treated to lessen their radioactivity, though the passage of time allows the radioactivity to decrease naturally. MW treatment can change the physical characteristics of the waste in such ways as to make it much less mobile, for example, thus reducing the threat to populace and environment. Vitrification or incorporation in grout are examples of this type of treatment.

d. Waste removal. The transport of the MW offsite for disposal is an alternative providing it satisfies specified remedial action requirements and satisfies DOT regulations of transport.

6-7. Additional Data Needs

Throughout the development of alternative remedial actions there will arise needs for more data. Those requirements must be identified and documented. The requirements for additional data must be classified as being critical to definition of the site/MW conceptual model or needed for alternative remedial action criteria. Data directly affecting understanding of contaminant distribution, transport, and concentrations are critical to the conceptual model against which the entire remedial program is designed. Sensitivity analyses may be used to determine if certain data needs are critical. Some data needs will require additional special-purpose investigations.

6-8. Feasibility Study Report

The identification and initial screening of remedial technologies will be reported. The development of alternative remedial alternative actions will be reported with the results of the initial screening of those alternatives. Those general subjects will comprise the feasibility study report. The report will include a summary of the background site information as reported from the remedial investigations. The nature and extent of the contamination will be described, together with a definition of the environmental media primarily addressed by the remedial alternatives. Each environmental medium of concern specified will be assigned preliminary remedial action objectives and will have general response actions identified. Potential remedial technology types will be identified and screened for applicability and accomplishment potential. Within each technology type the individual process options will be identified, matched to the site and environmental objective, and documented. Process options, technologies, and general response actions will be assembled into a range of remedial alternatives addressing the MW site rehabilitation objectives, and that assembly will be documented in the report. The methods by which the alternative action set was assembled will be reported. Impacts to the alternatives by regulatory controls will be described and necessary actions listed. Data that need to be incorporated in the remedial investigations will be documented. In the feasibility study report, there will be a complete definition of each alternative including the extent of remediation, the quantities of material involved in the actions, time estimates, required resources, and similar information sufficient to assess the feasibility of the alternative. The ground rules and bases for assessing feasibility will be reported. Initial screening evaluation results will be summarized.

6-9. Detailed Analysis of Remedial Action Alternatives

Additional phases of remedial investigations and feasibility studies are not explicitly required but may be necessary for large, or complex, or critical site restorations. Those phases of investigation and study will be increasingly more tightly focussed on specific problem areas and process evaluations. When all detailed analyses of technologies and processes are complete, the final feasibility study report will address nine criteria for each reported alternative remedial action. These criteria will serve as the basis for selection of the best protective and cost-effective remedial action. The nine required criteria for feasibility assessment are as follows.

a. Short-term effectiveness. This criterion addresses the following:

(1) Protection of the community during construction and implementation of the remedial action.

(2) Protection of workers during construction and implementation of the remedial action.

(3) Environmental impacts during construction and implementation of the remedial action.

(4) Time to elapse before the remedial action objectives are achieved.

b. Long-term effectiveness and permanence. This criterion addresses the risks remaining after the remedial action objectives have been met. These subjects include:

(1) Magnitude of the remaining risk from residual or untreated waste.

(2) Adequacy of controls required to manage residual or untreated wastes.

(3) Reliability of controls required for residual or untreated waste.

(4) Degree of permanence of the remedial action.

c. Reduction of toxicity, mobility, or volume. This criterion addresses, explicitly, the toxic component of MW. Implicit inclusion of the radioactive component must be made by association with full realization that the hazard of radioactive waste exists whether or not the regulatory language addresses it specifically. Generally speaking, radioactive materials cannot be changed to make them less radioactive. However, their physical forms can be changed to make them structurally and chemically more stable and less mobile. Specific factors include the following:

(1) Treatment and stabilization processes, their methods, and the materials they will address.

(2) The amount of MW that must be treated, stabilized, or disposed of.

(3) The degree of expected reduction in toxicity, mobility, or volume or increased physical or chemical stability.

(4) The degree to which treatment or stabilization is irreversible or the retrievability of disposed waste.

(5) The type and quantities of residual material that will remain.

d. Implementability. Both technical and institutional adequacy of an alternative remedial action will be addressed.

(1) Technical feasibility will include construction and operation of the alternative, the reliability of the particular technology, the ease of combining additional remedial actions, and the ease and completeness of monitoring efforts in the presence of the alternative.

(2) Adequacy of the alternative in the light of regulatory and other institutional controls.

(3) The availability of services and materials needed by the alternative.

e. Cost. Costs for the alternatives will be analyzed and compared based on a single figure for a common year. Reasonable and uniform discounting rates will be established for a probable period of performance of the remedial action. Sensitivity analyses may be used for costing feasibility studies so long as the practice is uniform among the alternatives.

f. Compliance with regulatory controls. Detailed analyses will summarize federal and state standards, requirements, criteria, and limitations that may be applicable, relevant, and appropriate to an alternative. The manner by which the alternative addresses the standards, requirements, etc. will be described. Pertinent waivers will be specified.

g. Overall protection of human health and the environment. This is the ultimate criterion as it explicitly arises from the objectives of both the CERCLA and the NEPA. Each source of contamination will be related to the alternative as well as each pathway of transport. Pursuant to the NEPA, the potential environmental impacts of any alternative should be addressed in the feasibility study report. There will be a final assessment of the risks to the general public and to the environment which will arise from the mitigated hazard.

h. State acceptance. This assessment will be preliminary in nature and consist only of fully documented prior comments by state agencies. Final acceptance by the state can only occur following the state review of the feasibility study report.

i. Community acceptance. As with state acceptance, assessment of community acceptance of particular alternatives can only occur in final form after review of the feasibility study report. Preliminary comments, if formally documented and if arising from the impacted community and special interest groups, may be included.

Chapter 7
Remedial Design and Remedial Action

7-1. Introduction

a. Hazardous waste. A variety of options have been identified for remedial response and remedial actions at hazardous waste sites (EPA 1982, EPA 1988b). EPA guidance provides a framework or methodology for evaluating the feasibility and desirability of available methods. The regulations and guidance give strong preference for remedies that are highly reliable and provide long-term protection (EPA 1988b). In addition to the requirement for remedies to be protective of human health and the environment and to be cost-effective, other considerations for guiding the selection of remedial actions include the following:

(1) A preference for remedial actions that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as a principal element.

(2) Offsite transport and disposal without treatment is the least-favored alternative where practicable treatment technologies are available.

(3) The need to assess the use of permanent solutions and alternative treatment technologies or resource recovery technologies and use them to the maximum extent practicable.

Selection of remedial actions must also be based on site-specific conditions including the chemical and physical nature and extent of contamination, geological and geotechnical characteristics, and sociopolitical considerations. Broad categories of available remedial actions at hazardous waste sites include surface or subsurface treatment of air, water, soil, and other materials, and the treatment, storage, and disposal of the materials resulting from site remediation.

b. LLRW.

(1) Disposal. Disposal of LLRW or MW is the most common method of remediation. Design considerations for disposal of LLRW and MW must address:

(a) The method of removal of the LLRW.

(b) Assaying the LLRW or MW to determine disposal characteristics for the disposal site selected.

(c) Packaging in accordance with NRC and DOT regulations.

(d) Transport in accordance with NRC and DOT regulations.

(e) Coordination with state and compact officials for export, transportation through, and import of LLRW or MW.

(f) Disposal at a licensed disposal facility.

(2) Treatment. Treatment methods to reduce the radioactivity of a given radionuclide are impossible; the volume of a given radioactive waste form can be reduced by separation of radioactive components; or the concentration of radioactivity may be decreased by dilution. LLRW treatment methods are based on those two concepts and are commonly used to decontaminate tools, equipment, or components, to reduce volumes of radioactive materials, to improve waste forms, and to improve stability of the wastes. The resulting wastes are more amenable to safe handling and disposal, and the decontaminated tools, equipment, or components can be returned to service.

c. MW.

(1) Regulatory responsibility. Neither the regulations and guidance developed by EPA for hazardous or toxic wastes nor that developed by NRC for LLRW address the class of wastes defined as M W. EPA and NRC share responsibility for management storage and disposal of MW. EPA has jurisdiction over the hazardous waste components, while NRC regulates LLRW. As discussed previously, states may regulate hazardous waste and LLRW generated or disposed of within their borders through exercise of rights and responsibilities granted to them under RCRA authorization and agreement state status, respectively. States can also seek MW authorization, to regulate storage and disposal of MW within their borders.

(2) Regulatory guidance. To date, EPA and NRC have developed three joint guidance documents to assist waste generators, state regulatory agencies, and other involved parties (e.g., DOE) with identification and definition, conceptual designs, and siting guidelines for MW disposal facilities. These guidance documents are described in appendixes to this EM. Joint guidance for remediation of sites with contamination by MW has not been specifically developed to date. However, MW generators and parties responsible for remediation of

MW-contaminated sites must comply with the appropriate EPA regulations dealing with the hazardous waste constituents and NRC or equivalent state regulations dealing with the LLRW constituents. If conflicts arise in satisfying the dual regulations, exemptions can be sought from RCRA requirements on a case-by-case basis, as discussed in section 1006 of RCRA. The general procedure for filing a petition for variance is discussed in the joint EPA/NRC guidance document (NRC-EPA 1987a, b, and c).

(3) Remedial options. In the following paragraphs, the remedial options available for LLRW and hazardous wastes are summarized. 40 CFR 268, "Land Disposal Restrictions, " bears directly on the choice of alternatives for the treatment or disposal of MW. 40 CFR 268.35 D and E require the hazardous component MW to be treated to meet LDR exposure requirements. Very few waste treatment facilities have the capability of handling the radioactive components while treating the hazardous components. Remediation efforts at sites contaminated by MW, or where MW wastes are stored, should be guided by integrating the separate regulations, guidance, and remedial options for LLRW and hazardous wastes. Trade-offs, compromises, and negotiations with the regulatory authorities may be necessary in many cases to achieve effective cleanups that protect the environment and public health and safety.

7-2. LLRW and MW Treatment

a. Treatment options. As mentioned in the introduction to this section, treatment options for LLRW are limited essentially to altering the form of the waste. In general, treatment methods may be used to decontaminate equipment, tools, components, or structures, to reduce volumes, to improve waste forms, or improve stability of wastes. Reduction of waste volume increases the radionuclide concentration. Separation of the waste into unmixed components may simplify waste management. In many cases the radioactive component of the residual waste remains a radioactive waste to be disposed of in a facility approved for radioactive waste. MW may contain hazardous components that are treatable to a nonhazardous status in such a way as to not disperse or otherwise accentuate the radioactive phase of the waste or generate new LLRW or MW. 10 CFR 61 allows such treatment with appropriate controls. This way the MW may, in some instances, be convertible to LLRW and disposed of as such.

b. Improvements. Improvements in waste form and stability are usually achieved by measures such as packaging wastes in durable containers, mixing wastes with cement slurries and placing them in durable containers or engineered structures, and compaction. Ion-exchange for removal of radioactively contaminated metal ions, such as is used to cleanse reactor cooling water supplies, is a technology employed to remove liquids, reduce volumes, and improve the waste form. Decontamination is the removal of radioactive material from where it is not wanted. Some decontamination methods can result in waste volume reduction, but others actually produce larger volumes of wastes that must be dealt with. Decontamination methods may be grouped into mechanical and chemical methods or into methods appropriate for removal of surface contamination and those useful for removal of deep contamination.

Chapter 8
Data Quality Management

8-1. Chemical Data Quality Management

a. General USACE controls. MW sites involve chemical contamination investigations, design, and remedial action activities. These activities must be conducted in full compliance with all applicable federal and state regulatory requirements. A plan for chemical data quality management (CDQM) is necessary to ensure full compliance and to assure chemical analytical data obtained are of sufficient quality to meet the intended usage within the project. ER 1110-1-263, "Chemical Data Quality Management for Hazardous Waste Remedial Activities," directs CDQM efforts for MW remedial action sites. ER 1110-1-263 includes:

(1) Guidelines for project-specific designation and validation of USACE Quality Assurance Laboratories.

(2) A listing of required CDQM submittals, including chemical data acquisition plans, quality control reports, quality assurance reports, and other documentation.

(3) A matrix of CDQM organizational responsibilities.

(4) A guide to USACE Chemical Quality Assurance Procedures.

(5) Contract laboratory validation procedures.

(6) A guide to preparation of the chemical data acquisition plan.

(7) A description of the components of USACE chemical quality assurance.

(8) Protocols for handling hazardous chemicals.

b. Data quality management relative 10 radioactive materials.

(1) USACE requirements. Examination of the general list above and the referenced ER shows no reference to radioactive and mixed waste materials. The procedural requirements in the ER apply to radioactive chemicals as well as nonradioactive chemicals and the absence of direct reference does not lessen the prescriptions for CDQM as applied to chemical analyses of samples from MW or LLRW sites. Where direction from the ER is incomplete, the guidelines of DOE and other agencies may be applied, together with case-by-case special controls of radiological data quality management that are fully documented and approved upwards through USACE.

(a) Quality assurance procedures incorporating radiological considerations. There is no scientific or technical reason why radioactive material analyses cannot be treated in the management and reporting schemes as a part or facet of CDQM. Some laboratories will not be eligible to be selected or validated for radiochemistry analysis services because of lack of capability, but the services are available elsewhere. Because radioactive materials are incorporated in the samples from an MW site, it will be necessary to verify the candidate laboratory radiation safety procedures and pertinent permits from local, state, and federal agencies. Examination of the guidelines for commercial laboratory validation and monitoring indicates nothing predicating against radiochemistry analyses being performed under the same basic guidances.

(b) Validation of USACE quality assurance (QA) and contract laboratories. The pertinent USACE District or Division initiates the designation of a Division QA laboratory and HTRW MCX approves and executes the designation. The QA laboratory, the scope of services desired, and any contracted laboratory analysis services that deal with MW must have personnel and equipment validated to be capable of handling radioactive materials. Storage and ultimate disposal of samples will be a complicating factor for many otherwise capable laboratory facilities. The disposal or cleaning of radioactively contaminated laboratory equipment and expendable supplies must be addressed as part of the validation of a laboratory. Some equipment items and services, specifically spectroscopic or activation analysis systems, may be more efficiently obtained under commercial contract than from USACE laboratories. The laboratory will require the presence of personnel trained in radiation protection practice and the adequate use of radiation monitoring equipment and other protective practices.

(c) Radiological data acquisition. A site-specific chemical data acquisition plan (CDAP) is a document required from a contractor or USACE office responsible for chemical data at hazardous waste sites. Because MW contains (by definition) chemically hazardous components, a CDAP will be required for remedial activities at MW sites. That CDAP will incorporate radiological data acquisition components. In the case of LLRW sites where the contamination is not strictly due to hazardous or toxic chemicals, the guidance for developing a CDAP provided in Appendix D of ER 1110-1-263 will be used in appropriately augmented or adapted form for preparation of a CDAP emphasizing radioactive materials.

(2) Requirements of other agencies. General EPA quality assurance guidance is found in QAMS 005/80, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans" (EPA 1983). The DOE and the nuclear industry regulated by the NRC follow quality assurance guidance issued by the American Society of Mechanical Engineers, NQA-1 (1989 edition), "Quality Assurance Program Requirements for Nuclear Facilities." These two documents form the basis for ANSI/ASQC-E4, 'Quality Assurance Program Requirements for Environmental Programs," which will be endorsed by DoD, DOE, and EPA after finalization. Detailed radioactivity data management directives which are site-specific are various issues of *Environmental Investigation Instructions* developed by the commercial operators of major DOE facilities, such as Hanford (Westinghouse Hanford Company 1989a and b). General directives concerning radioisotopic analyses are provided by the DOE Office of Environmental Restoration and Waste Management in "DOE Methods for Evaluating Environmental and Waste Management Samples" (DOE 1994). These are directives addressing environmental survey methods to be used on DOE sites to determine the existence and level of hazardous materials. The practices described below would be considered as "screening-level" measurements performed in the preliminary assessment and remedial investigations. The practices would be performed in appropriately qualified laboratory conditions on all recovered samples until accumulated information indicated discontinuance of radioactivity screening at particular locations.

(a) Gross alpha measurements are intended to indicate the presence of uranium, thorium, plutonium, americium, neptunium, radium, and other TRU elements. Gross beta measurements indicate the presence of strontium-90, radium-228, and cesium-137. Radon-222, a common decay product of radium, is difficult to detect and quantify and requires specialized investigation. The gross alpha count will be done on all samples potentially contaminated with an alpha-emitting radioisotope. Likewise, the gross beta count will be done most commonly using a low-background proportional counter on all samples potentially contaminated with a beta-emitting radioisotope. Tritium, carbon-14, and radioisotopes of iodine are, however, serious contaminants which require different, specialized detection methods. Specific isotopes will be determined only if the gross alpha measurement, or the gross beta measurement, is greater than the instrument's natural background by a specified factor. The detection limit in radiochemistry is often accepted as three times the square root of the instrument background so the action level for further analyses must be greater than that to prevent costly false positives.

(b) A spectroscopic scan of gamma radiation from a sample is a simultaneous determination of the presence, identification, and quantification of particular gamma-emitting radioisotopes. The DOE-specified gamma scan is a 1,440-min accumulation of gamma radiation using a sodium iodide detector; however, site-specific contaminant species and energies may justify shorter counting periods. The most common radionuclides that are determined by a gamma scan are cesium- 137, cobalt-60, and potassium-40. Other, more exotic radionuclide species are determinable if their concentrations are high enough.

(c) DOE environmental survey practices treat uranium and other specific radionuclides distinctly (DOE 1987). The presence and total concentration of uranium will first be determined chemically; then, if requested, the relative isotopic concentrations will be measured. The concentrations of plutonium, thorium, radium, strontium, and iodine are also to be measured chemically first, if requested, and the isotopic concentrations as requested. The radioisotopes tritium (hydrogen-3) and radon-222 require specialized analysis procedures. An alternative to the DOE environmental survey practices cited above may be more efficient and more suited to sites other than DOE. If the radioisotopic concentrations are desired, the radiochemical analyses for those concentrations may be performed and the separate isotopic concentrations added to provide total concentration.

8-2. Geotechnical Data Quality Management

a. GDQM responsibilities. Geotechnical data quality management (GDQM) is the development and application of policies and procedures to assure that quality geological and geotechnical data are obtained and used throughout the planning, characterization, design, construction, and operation of a project (Department of the Army 1992). The procedural requirements in the ER apply to radioactive chemicals as well as nonradioactive chemicals and the absence of direct reference does not lessen HQUSACE responsibility for GDQM implementation and execution support and oversight responsibilities for USACE-managed projects. USACE HTRW MCX has primary responsibility for assuring implementation of GDQM requirements in support of Superfund, DERP, Civil Works Water Resource projects, and non-mission

HTRW efforts. USACE HTRW MCX conducts technical reviews of GDQM predesign and design documentation. The USACE element responsible for executing predesign and design activities develops all GDQM documentation and assures that quality field work is done. The pertinent geographic USACE Division or District has responsibility for contract administration and quality assurance of HTRW remedial actions. Detailed, explicit guidance is provided therein for the installation of monitoring wells at HTRW sites. Requirements and protocols specific to sites contaminated with LLRW or MW will be added to this document as they are established.

b. Geotechnical data assurance plan. A document detailing the geotechnical data acquisition activities required on a project site should be a USACE contract requirement. This document should describe the planned geophysical program, hydrological and vadose zone investigation and testing program, geotechnical sampling and testing program, and topographical survey requirements. The document should present the rationale for each activity and the quality control measures to be used throughout the field and laboratory program, as well as the deliverables required. Detailed requirements should be specified in the contract documents.

Chapter 9
Quality Assurances and Controls for Remedial Actions at LLRW and MW Sites

9-1. Introduction

a. Cleanup of sites. This chapter provides guidance to any party involved with the cleanup of controlled or uncontrolled LLRW AND MW sites. Overall guidance is obtained from ER 1110-1-12, "Quality Management. " General policy and guidance for establishing quality management procedures in the execution of construction contracts are provided by ER 1180-1-6, "Construction Quality Management. " Construction quality management programs are well-established within USACE and apply directly to LLRW and MW site remediation activities. The guidance presented herein is directed towards quality assurance/quality control (QA/QC) of remedial actions specifically at LLRW and MW sites and is modeled after the document "Quality Assurance Guidance for Low-Level Radioactive Waste Disposal Facility, " NUREG-1293 (NRC 1989). The document describes 18 quality control criteria which are basic to any QA program, but specifically addresses LLRW disposal. Because M W is characterized by a radioactive component, these quality control criteria are directly applicable to MW site restoration. The guidance presented herein describes the same 18 criteria (some are identical) while addressing remedial operations, including onsite disposal of radioactive waste. This guidance is oriented towards the actual remedial actions. Similar QA/QC considerations are required during the remedial investigation/feasibility study phases of effort at the site. For purposes of chemistry (including radiochemistry) data acquisition during remedial investigations, ER 1110-1-263 will be followed. Specifically, investigative data quality objectives are to be developed by the contractor for the areas of chemical, radioactivity, and geotechnical data acquisition and interpretation. These data quality management objectives will then be implemented through data acquisition plans (e.g., CDAP), which will specify the controls on the quality of the data-gathering efforts.

b. Responsibilities. Remedial operations often involve more than one responsible party and supporting organization, yet one party must be solely responsible for the content and success of the QA program. The responsible party must oversee all contractors' and subcontractors' QA programs and assure their compliance with the criteria presented here. The responsible party will be assumed to be USACE in the following discussion.

9-2. Organization of QA/QC Programs

The lead agency concerned with an MW site shall be responsible for the establishment and execution of the QA program. DOE Order 5700.6B is a directive written specifically for QA at Hanford, though it will provide insight into broadly applicable QA program requirements at DOE sites. The work of establishing and executing the QA program may be delegated to contractors, agents, or consultants, but ultimate responsibility and control are retained by the leader. The lead agency will establish, define, and delineate in writing the functions and responsibilities of each delegated organization required to perform "quality achieving" and "quality assuring" activities. The persons and organizations performing quality assuring functions must be allowed sufficient authority to identify problems with quality, recommend solutions, and verify implementation of solutions. To ensure accomplishment of QA goals, individuals assigned the responsibility for ensuring effective execution of any portion of the QA program should have direct and meaningful access to the levels of management necessary for fulfillment of this responsibility.

9-3. QA Program Plan

a. Plan development. The lead agency will provide, as early as possible, a QA program plan (QAPP) that complies with current guidance. EPA (1983) 600/4 - 83/004 provides guidelines and specifications for preparing the QAPP. The QAPP will document policies, procedures, and guidance which should be carried out through the entire remediation process, from characterization and licensing for disposal through monitoring and closing of a site. Activities, structures, systems, and components of the remediation program will be identified along with major participating organizations and their designated functions.

b. QAPP objective. The QAPP will provide control over remedial activities effecting quality and address the need for special controls, processes, test equipment, tools, and skills to attain the required quality of defined activities, structures, systems, and components.

9-4. Quality Control

The QA program will provide indoctrination and training for personnel to ensure understanding of QA requirements and the importance of the requirements. Environmental training for HW and LLRW personnel is offered by USACE and the EPA. The QA program should be reviewed regularly for adequacy and should be in effect until closure of the site.

a. Design controls.

(1) Designs are controlled by ER 1110-345-100, “Design Policy for Military Construction, ” ER 1110-345-700, “Design Analyses, ” ER 1110-345-710, “Drawings,” and ER 1110-345-720, “Construction Specifications. ”

(2) Design controls should ensure that required regulations are correctly translated into specifications, drawings, procedures, and instructions for remedial action. This section gives a brief description of necessary design controls. Specifically, geotechnical aspects of remedial design controls are extensively reported in NUREG/CR-3356, “Geotechnical Quality Control: Low Level Waste and Uranium Mill Tailings Disposal Facilities” (Johnson, Spigolon, and Lutton 1983).

(3) The design control program should be documented and implemented before design work begins. The design control program should specify appropriate quality standards to be included in design documents. Any deviation from such standards shall be documented. The program should contain measures to ensure suitability of selected materials, parts, equipment, and processes essential to the functions of the systems, structures, and components of the operation.

(4) Design control includes the following:

(a) Measures to ensure verification or checking of design adequacy.

(b) Identification of positions or organizations responsible for design verification.

(c) Description of the measures taken to ensure verification is performed by individuals other than those responsible for the original design.

b. Procurement document control. Procurement documents for the purchase of materials, equipment, or services should include or reference applicable regulatory requirements, design bases, and other requirements needed to assure adequate quality. Qualified personnel should review and agree on the adequacy requirements stated in procurement documents. This review should be documented. Procurement documents must clearly describe the procedures to be followed, records to be generated and retained for field services, and identification of documentation to be prepared and submitted to the purchaser.

c. Instructions, procedures, and drawings. Approved instructions, procedures, and drawings are needed for the performance of designated activities, structures, systems, and components of the remedial action to provide criteria for verification and ultimately demonstrate that the action was performed according to the technical requirements.

d. Document control.

(1) Objective. Measures shall be established which control the issuance of documents (e.g., instructions, procedures, drawings) which describe all activities pertaining to quality. These documents should be reviewed for adequacy and approved by authorized personnel before being released and used at the location of the activity. Changes to the documents shall be subject to the same procedure of review and approval as the original documents.

(2) Litigation. Document control is extremely important in the event of litigation. EPA report No. 330/9-78-00 l-R, “National Enforcement Investigation Center, Policies and Procedures, ” (EPA 1978) has an extensive program for document control which should be closely reviewed even if litigation is not pending.

(3) Remediation. Document control specifically for remediation measures is addressed in the EPA report No. 540/G-85/002 (EPA 1985a), “Guidance on Remedial Investigations Under CERCLA. ”

e. Control of purchased material, equipment, and services. Purchasing controls should ensure that material, equipment, and services purchased conform to procurement document requirements, and appropriate evaluation and selection of possible sources are reviewed before the purchase. Also, documented evidence of procured items meeting requirements of procurement documents should be furnished by the supplier upon receipt of the items. This document should be kept onsite and available before the item(s) is used. Inspection of the suppliers’ facility by the purchaser, in accordance with written procedure, should be conducted during any phase of design, manufacture, or testing of the procured item to ensure quality. Periodic verification of suppliers’ certificates of conformance should be performed to ensure validity.

f. Identification and control of material, parts, and components. This criterion ensures formal control and identification of items (e.g., core, laboratory test samples, materials to be used in construction, and materials found defective) used during all phases of remedial action. Items should be properly identified, where appropriate, with identification on the item itself or maintained on records traceable to the original item. Identification measures should be designed to prevent the use of incorrect or defective material, parts, and components.

g. Control of processes. Processes affecting the quality of items or services should be described by formal instructions, procedures, drawings, checklists, or other appropriate means. The description should specify the level of operator skills required for performing the process. Qualification records of personnel associated with said processes should be established and kept current.

h. Inspection. Inspection is a means of accepting or rejecting completed work. It can also verify that work or prior inspections have been performed properly.

(1) Inspection objectives. A program for inspection should describe measures to ensure that inspection personnel are qualified and independent of the activity being inspected, indirect control by monitoring is used if direct inspection is inadequate, both inspection and process monitoring are conducted when necessary to ensure quality, inspection procedures will be available before the inspections are performed, and replaced, modified, or repaired items are inspected as original items.

(2) Inspection documentation. Documents will be necessary to identify mandatory inspection hold points that require witnessing or inspecting, beyond which work may not proceed without consent of a designated individual.

i. Test control. A test program shall be established to ensure satisfactory performance of structures, systems, and components. Tests shall be performed by qualified personnel in accordance with written test procedures that contain acceptable limits and requirements from applicable design documents. Test procedures shall ensure all test prerequisites are met and adequate instrumentation and suitable environmental conditions are available. Test results should be documented and retained onsite as verification that test requirements have been satisfied.

j. Control of measuring and test equipment. Requirements for the calibration of monitoring equipment are contained in AR 40-14, "Control and Recording Procedures for Occupational Exposure to Ionizing Radiation," and AR 385-11, "Ionizing Radiation Protection." Procedures for carrying out the calibration of monitoring equipment are given in Technical Bulletin (TB) 9-6665-285-15, "Army Calibration Program for Radiac Meters."

k. Handling, storage, and shipping. Measures should be made to control the handling, storage, packaging, and shipping of items affecting the quality of remedial operations. Special attention must be paid to the care of samples obtained for site characterization and design. These samples must be prevented from loss, damage, deterioration, and misidentification and, if necessary, special provisions should be specified to prevent contamination or damage due to adverse environmental conditions. All items should be handled in accordance with design and specification requirements. Identification of samples and items must be verified and maintained when being transported or transferred from one organization's responsibility to another.

1. Inspection, test, and operating status. The purpose of this criterion is to identify the status of tested and/or inspected items. Measures should be taken to tag, stamp, or label items with results of the most recent test or inspection to prevent the inadvertent use of defective items and the bypassing of such inspections or tests. In addition, the operating status of structures, systems, and components of the remedial operation should be identified to preclude inadvertent operation.

m. Nonconforming materials, parts, or components. A procedure should be established for control of materials, parts, or components that do not conform to requirements to prevent their use. Measures should provide for appropriate identification, documentation, segregation, deposition, and notification to affected organizations. These items should then be reviewed and accepted, rejected, repaired, or reworked in accordance with documented procedures.

n. Corrective actions. Corrective measures should be described which ensure that conditions adverse to quality, such as failures, malfunctions, deficiencies, derivations, defective material and equipment, and nonconformances are promptly identified and corrected. In the case of significant conditions adverse to quality, measures should be taken to identify, document, and report to management the cause of the condition and the corrective action needed. Significant conditions are those which seriously affect safety, reliability, or performance.

o. Quality assurance records. Quality assurance records are the most important evidence that quality-assuring activities have been properly performed. These records should be carefully controlled with specifications for content, identification, storage, and access. Record content should include as a minimum the following: operating logs and the results of reviews, inspections, tests, audits, monitoring of work performance, and material analysis. Additional related data can be included such as personnel, equipment, and procedure qualifications. Inspection and test records need to identify the inspection or data recorder, the type of observation, the results, the acceptability, and corrective action taken, if any. A plan should be established describing the retention of records, such as duration, location, and assigned responsibility in accordance with applicable regulatory requirements.

p. Audits, surveillance, and managerial controls. A comprehensive plan of audits, surveillance, and managerial controls should be established to determine the effectiveness of the quality assurance program. Periodic audits should be conducted, according to written procedure, by qualified personnel not directly responsible for the area being audited. The results of the audit shall be documented and reviewed by management personnel having responsibility in the area audited. The plan should include frequency of audits; documentation, review, and record maintenance of the audit program; follow-up action, including correction and surveillance. The plan should measure and record the status of the remedial action as it relates to meeting regulatory requirements and identifies problems in a real-time framework for timely mitigation.

Appendix A
References

ER 385-1-80
Radiological Safety

ER 385-1-92
Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) and Ordnance and Explosive Waste (OEW) Activities

ER 1110-1-12
Quality Management

ER 1110-1-263
Chemical Data Quality Management for Hazardous, Toxic, Radioactive Waste Remedial Activities

ER 1110-345-100
Design Policy for Military Construction

ER 1110-345-700
Design Analyses, CH 1

ER 1110-345-710
Drawings, CH 1

ER 1110-345-720
Construction Specifications

ER 1180-1-6
Construction Quality Management

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Appendix B
Glossary

B-1. Abbreviations and Acronyms

AE . . . . Architect-engineer
AEC . . . . Atomic energy commission
ALARA . . . . As low as reasonably achievable
AMCCOM . . . . Armament, Munitions, and Chemical Command
ARAR . . . . Applicable or relevant and appropriate requirement

BWR . . . . Boiling water reactor

CDQM . . . . Chemical data quality management
CDAP . . . . Chemical data acquisition plan
CE . . . . Corps of Engineers
CENWD . . . . Corps of Engineers Northwestern Division
CERCLA . . . . Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)
CFR . . . . Code of Federal Regulations
CFC . . . . Chlorofluorocarbon
CHP . . . . Certified health physicist
CIH . . . . Certified industrial hygienist
CMI . . . . Corrective measures implementation
CMS . . . . Corrective measures study

DAC . . . . Derived air concentration
DERP . . . . Defense Environmental Restoration Program
DoD . . . . Department of Defense
DOE . . . . Department of Energy
DOE-RL . . . . Department of Energy-Richland Operations Office
DOT . . . . Department of Transportation

EC . . . . Engineer Circular
EM . . . . Engineer Manual
EPA . . . . U.S. Environmental Protection Agency
ER . . . . Engineer Regulation
ERDA . . . . Energy Research and Development Administration
ETL . . . . Engineer Technical Letter

FAR . . . . Federal acquisition regulations
FOA . . . . Field Operating Activity
FS . . . . Feasibility study
FUDS . . . . Formerly used defense site

GDQM . . . . . . Geotechnical data quality management

HEPA . . . . High-efficiency particulate air
HLRW . . . . High-level radioactive waste
HQUSACE . . . . Headquarters, U.S. Army Corps of Engineers
HAP . . . . Health and safety plan (see SSHP)
HSWA . . . . Hazardous substances and waste amendments
HTW . . . . Hazardous/toxic waste
HTRW . . . . Hazardous/toxic/radioactive waste
HOOP . . . . Hazardous waste operations permit

IA . . . . Interagency agreement

LANL . . . . Los Alamos National Laboratory
LINAC . . . . Linear accelerator
LLRW . . . . Low-level radioactive waste

MCX . . . . Mandatory Center of Expertise
MOA . . . . Memorandum of Agreement
MOB . . . . Memorandum of Understanding
MSC . . . . Major Subordinate Command
MAR . . . . Minimum technology requirements
MW . . . . Mixed waste

NCP . . . . National Contingency Plan
NEPA . . . . National Environmental Policy Act
NOSH . . . . National Institute for Occupational Safety and Health
NPL . . . . National Priorities List
NRC . . . . Nuclear Regulatory Commission
NTS . . . . Nevada test site

OCONUS . . . . Outside Continental United States
ORNL . . . . Oak Ridge National Laboratory
OSHA . . . . Occupational Safety and Health Administration
OSWER . . . . . . Office of Solid Waste and Emergency Response
OVA . . . . Office of Technology Assessment

PA . . . . Preliminary assessment
PPE . . . . Personal protective equipment
PVT . . . . Polyvinylchloride
PWR . . . . Pressurized water reactor

QA . . . . Quality assurance
QAPP . . . . Quality assurance program plan
QC . . . . Quality control

RA . . . . Remedial action
RCRA . . . . Resource Conservation and Recovery Act of 1976
RD . . . . Remedial design
RFA . . . . RCRA facility assessment
RFI . . . . RCRA facility investigation
RI . . . . Remedial investigation
ROD . . . . Record of decision
RWP . . . . Radiation work permit

SARA . . . . Superfund Amendments and Reauthorization Act of 1986
SARS . . . . Safety analysis and review system
SI . . . . Site inspection
SOP . . . . Standard operating procedure
SSHP . . . . Site safety and health plan
SRP . . . . Savannah River Plant

TRU . . . . Transuranic
TCL . . . . Toxicity characteristic leaching procedure

USACE . . . . U.S. Army Corps of Engineers
USEPA . . . . . U.S. Environmental Protection Agency

B-2. Terms

ACCURACY: For purposes of environmental investigations, a measure of the systematic error that contributes to the difference between the arithmetic average of a set of measurements and an accepted reference or true value.

ACTIVE MAINTENANCE: Any significant remedial activity needed during the period of institutional control to maintain a reasonable assurance that the performance objectives in pertinent regulations are met. Such active maintenance includes ongoing activities such as the pumping and treatment of water from a disposal unit or one-time measures such as replacement of a disposal unit cover. Active maintenance does not include custodial activities such as repair of fencing, repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, minor repair of disposal unit covers, and general disposal site upkeep such as mowing grass.

ACTIVITY: A measure of the rate at which a material is emitting nuclear radiations; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time; the standard unit of activity is the Curie (Ci), which is equal to 3.7×10^{10} disintegrations per second (alps). The SI unit is the Becquerel (Bq), equal to 1 alps.

AGREEMENT STATES: Any states with which the Nuclear Regulatory Commission, the Department of Energy, or the Atomic Energy Commission has entered into an effective agreement under subsection 274b of the Atomic Energy Act of 1954. Agreement states have established a well-defined distribution of responsibilities between their agencies and those of the federal government. A nonagreement state is any other state, which will abide entirely by federal law and regulation. (10 CFR 150.3)

ALARA “As Low As Reasonably Achievable”: A policy for maintaining exposures (individual and collective) as low as is reasonable, taking into account social, technical, economic, practical and public policy considerations. ALARA is not a dose limit but a standard of excellence that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable.

ALPHA RADIATION: One of the particles emitted in radioactive decay; identical in mass with the nucleus of the helium atom, consisting of two protons bound with two neutrons; loses energy rapidly when traversing through matter, e.g., natural alpha radiation can traverse only a few centimeters of air before being halted.

ANION: Ion with negative net electrical charge.

AQUICLUDE: A geological formation which, although porous and capable of absorbing water, does not transmit it at rates sufficient to furnish an appreciable supply for a well or spring.

AQUIFER: A geological stratum or set of beds with relatively high transmissivity and carrying groundwater in quantities to make exploitation for consumption economically feasible; a *confined aquifer is* bounded above and below by aquicludes and is characterized by its ability to force its water higher in elevation than its top boundary; an *unconfined aquifer is* not bounded by an overlying aquiclude and its upper surface is called the *water table.*

BACKGROUND RADIATION: Radiation in the environment from naturally occurring radioactive isotopes, cosmic radiation, and fallout from man’s activities such as nuclear weapons testing.

BETA RADIATION: One of the particles emitted during radioactive decay; negatively charged beta particles are identical in mass and electrical charge to the electron. The positively charged type is called a *positron.*

BIOASSAY: Measurement of radioactive material deposited within or excreted from the body. This process includes whole body and organ counting as well as urine, fecal, and other specimen analysis.

BUFFER ZONE: A portion of the disposal site that is controlled by the licensee and that lies under the disposal units and between the disposal units and the boundary of the site.

CATION: Ion with positive net electrical charge.

COMBINED or CO-MINGLED WASTE: Waste that contains a radioactive component and a hazardous component, and does not meet the strict definition of a mixed waste.

CONFINEMENT AREA: An area having structures or systems from which releases of hazardous materials are controlled. The primary confinement systems are process, handling, storage, or disposal enclosures which are surrounded by one or more secondary confinement areas.

CONFINEMENT SYSTEM: The barrier and its associated systems (including ventilation or drainage) between areas containing hazardous materials and the environment or other areas in the facility that are normally expected to have levels of hazardous materials lower than allowable concentration limits.

CURIE (Ci): A unit of radioactivity defined as the amount of a radioactive material that has an activity of 3.7 x 10 disintegrations per second (alps); milliCurie (mCi) = 10^{-3} Curie; microCurie (μCi) = 10^{-6} Curie; nanoCurie (nCi) = 10^{-9} Curie; picoCurie (pCi) = 10^{-12} Curie; femtoCurie (fCi) = 10^{-15} Curie.

DATA QUALITY MANAGEMENT: The combination of activities establishing a quality assurance program and quality control operations that address the acquisition and treatment of data by commercial contractors or governmental personnel and organizations; includes the maintenance of field and laboratory practices and validations of those practices and the resultant interpretations so as to ensure the achievement of explicitly stated data quality objectives; treated by technical area as *Chemical Data Quality Management, Radiological Data Quality Management,* and *Geotechnical Data Quality Management;* performed functionally by establishing *Data Quality Objectives, Data Management Specifications, Data Acquisition Plans,* and *Quality Assurance Reports* for each of the technical areas.

DECONTAMINATION: The selective removal of radioactive and/or hazardous material from a surface or from within another material.

DERIVED AIR CONCENTRATION (DAC): The concentration of a radionuclide in air that, if breathed over the period of a work year, would result in the ALI for that radionuclide being reached.

DISPOSAL SITE: That portion of a land disposal facility which is used for disposal of waste. It consists of disposal units and a buffer zone.

DISPOSAL UNIT: A discrete portion of the disposal site into which waste is placed for disposal. For current near-surface disposal, the unit is usually a trench.

DOSE: The amount of energy deposited in body tissue due to radiation exposure. Various technical terms, such as 'dose equivalent,' 'effective dose,' 'equivalent,' and 'collective dose,' are used to evaluate the amount of radiation an exposed worker receives.

Dose equivalent, measured in units of rem, is used to take into account the difference in tissue damage from different types of ionizing radiation.

Technical definitions for dose terms include the following:

Absorbed dose (D): Energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The units of absorbed dose are the rad and the Gray (Gy). 1 Gray equals 100 rad.

Dose equivalent (H_T): The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and Sievert (Sv). 1 Sievert equals 100 rem.

Effective dose equivalent (H_E): The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma W_T H_T$).

Committed dose equivalent ($H_{T,50}$): The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by a person during the 50-year period following the intake.

Committed effective dose equivalent ($H_{E,50}$): The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50}=\Sigma w_T H_{T,50}$).

Total effective dose equivalent (TEDE): The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Shallow dose equivalent: Applies to the external exposure of the skin or an extremity. It is taken as the dose equivalent at a tissue depth of 0.007 cm averaged over an area of 1 cm^2.

Weighting factor: Factor that represents the proportion of the total stochastic (cancer plus genetic) risk resulting from irradiation to tissue to the total risk when the whole body is irradiated uniformly.

ENGINEERED BARRIER: A man-made structure or device that is intended to improve a land disposal facility's ability to meet the performance objectives in pertinent regulations.

ENGINEERED DISPOSAL: The disposal of hazardous and toxic waste, often in suitable sealed containers in any of a variety of structures especially designed to protect them from water and weather and to prevent leakage to the biosphere by accident or sabotage.

ENVIRONMENTAL SURVEILLANCE: Monitoring of the impact on the surrounding region of the discharges from industrial operations, forest fires, storm runoff, or other natural or man-induced events.

EXPOSURE: A measure of the ionization produced in air by X or gamma radiation. It is the quotient of (1) the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by (2) the mass of the air in the volume element. The special unit of exposure is the Roentgen equal to 2.58×10^{-4} Coulombs per kilogram. Acute exposure generally refers to a high level of exposure of short duration; chronic exposure is lower-level exposure of long duration.

GAMMA RADIATION: Electromagnetic waves emitted during radioactive decay; also called "nuclear x-rays"; highly penetrating, e.g., a substantial fraction penetrates several centimeters of lead.

GROUNDWATER: Water that exists or flows below the ground surface and that will flow into a well or from a surficial spring due to a pressure equal to or greater than atmospheric pressure.

GROUT: Fluid or semifluid material, often containing portland cement, which may be pumped or poured into earth strata and, by setting up into a solid state, provides mechanical stabilization or water flow control.

HALF-LIFE: The time in which enough of the atoms of a particular radioactive substance disintegrate to another nuclear form to reduce the radioactivity level by half. Measured half-lives vary from millionths of a second to billions of years. After a period of time equal to 10 half-lives, the radioactivity of a radionuclide has decreased to 0.1 percent of its original level.

HAZARDOUS WASTE: Those wastes designated as hazardous by Environmental Protection Agency regulations in 40 CFR Part 261.

HIGH-EFFICIENCY PARTICULATE AIR (HEPA) FILTER: A high-efficiency particulate air filter having a fibrous medium that produces a particle removal efficiency of at least 99.97 percent for 0.3-μm particles of dioetylphthalate (DOP) when tested in accordance with MIL-STD-282.

HIGH-LEVEL RADIOACTIVE WASTE (HLRW): The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic (TRU) waste and fission products in concentrations as to require permanent isolation; defined in section 1 le. (2) of the Atomic Energy Act of 1954.

HYDROGEOLOGY: The study of groundwater, with particular emphasis on its relation to the geologic environment, the mode of migration, and chemistry.

HYDROGEOLOGIC UNIT: Any soil or rock unit or zone which, by virtue of its porosity or permeability or lack thereof, has a distinct influence on the storage or movement of groundwater.

IN SITU: In the natural or original position; used to refer to in-place experiments at a storage or disposal site.

INADVERTENT INTRUDER: A person who might occupy a disposal site after closure and engage in normal activities, such as agriculture, dwelling construction, or other pursuits, in which the person might be unknowingly exposed to radiation or chemical contamination from the waste.

INTRUDER BARRIER: A sufficient containment of the waste that inhibits human contact with waste and helps to ensure that radiation and chemical exposures to an inadvertent intruder will meet the performance objectives set forth in 10 CFR 61 or 40 CFR 261; or engineered structures that provide equivalent protection to the inadvertent intruder.

ION: Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.

ION EXCHANGE: A reversible interchange that takes place between ions of like charge, usually between ions present on an insoluble solid and ions in a solution surrounding the solid. An important process in both fundamental and industrial chemistry.

ION EXCHANGE RESIN: An insoluble polymerized electrolyte that contains either acidic groups for exchanging cations or basic groups for exchanging anions. It contains large, high-molecular-weight ions of one charge and small, simple ions of the opposite charge. The small ions undergo exchange with ions in solution.

IONIZING RADIATION: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

ISOTOPES: Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore differing in the mass number. Identical chemical properties exist between isotopes of a particular element. Stabilities of differing isotopes of a particular element may vary, hence their propensity to disintegration and half-life.

KARST: Surface or subsurface rock mass conditions characterized by solution-formed caverns, open joints, pinnacles, and depressions of a highly irregular form. Almost exclusively applied to carbonate lithologies, e.g., limestone, but may effectively be applied to evaporite lithologies also, e.g., gypsum. Can be a geological characterization implying highly irregular and difficult-to-predict geohydrological conditions.

LAND DISPOSAL FACILITY: Land, buildings, and equipment intended to be used for the disposal of radioactive and/or hazardous wastes into the subsurface of the land. A geologic repository as defined in 10 CFR 60 is not considered a land disposal facility. (10 CFR 61.2)

LEACHATE: A solution containing dissolved and finely suspended solid matter and microbial waste products resulting from groundwater or infiltrating surface water seepage through solid waste.

LEACHING: The process of extracting a soluble component from a solid by the percolation of a solvent (e.g., water) through the solid.

LIQUEFIABLE: Susceptible to near-total loss of shear strength and bearing capacity during seismic disturbances; used with reference to soils.

LITHOLOGY: The character of a rock formation or of the rock found in a geological area or stratum expressed in terms of its structure, mineral composition, color, and texture.

LOW-LEVEL RADIOACTIVE WASTE (LLRW): Radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or uranium and thorium mill tailings.

MIXED WASTE (MW): Waste containing both a radioactive component defined by the Atomic Energy Act (source, byproduct or special nuclear material) and a hazardous component defined in the Resources Conservation and Recovery Act (listed or characteristic wastes).

MONITOR WELL: Device designed and constructed for acquisition of groundwater samples that are representative of the chemical quality of the aquifer/groundwater adjacent to the screened interval and isolated from the overlying and underlying geologic and hydrologic materials; with appropriate design provides access to measure the potentiometric surface of the particular confined aquifer or the water table.

NEAR-SURFACE DISPOSAL FACILITY: A land disposal facility in which radioactive waste is disposed of in or within the upper 30 m of the earth's surface.

PERMEABILITY: The capacity of a porous medium to conduct liquids or gases. Dependent on the viscosity and other characteristics of the conducted fluids and ambient conditions.

PIEZOMETER: An instrument for measuring pressure head in groundwater. In an unconfined aquifer (that with a water table) a piezometer is frequently an open-bottomed monitor well extending below that water table.

PRECISION: A measure of the repeatability or reproducibility of a particular measurement under a given set of conditions; a measure of variability; commonly expressed in terms of standard deviation or in terms of range.

PSYCHROMETER: Device used for measuring the amount of water vapor in air; e.g., a hygrometer.

PYROPHORIC: Igniting spontaneously. A pyrophoric liquid is any liquid that ignites spontaneously in dry or moist air at or below 130 “F (54.5 “C). A pyrophoric solid is any solid material, other than one classed as an explosive, which under normal conditions is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation, handling, or disposal hazard. Included are spontaneously combustible and water-reactive materials.

QUALITY ASSURANCE: All those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance (QA) includes quality control (QC), which is all those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements.

QUALITY ASSURANCE RECORDS: Includes results of reviews, inspections, audits, and material analyses; monitoring of work performance, qualification of personnel, procedures, and equipment; and other documentation such as drawings, special reports, and corrective action reports.

RAD: The unit of absorbed dose of ionizing radiation equal to 100 ergs per gram or 0.01 joule per kilogram.

RADICAL, CHEMICAL: A semi-stable fragment of the molecule of a molecular chemical compound; is comprised of more than one atom; carries an electrical charge, either positive or negative, but is not an ion which is a single electrically charged atom; because of unsatisfied electrical charge, is chemically reactive.

RADIOACTIVITY: The property of certain naturally unstable isotopes of spontaneously emitting particles or gamma radiation, or of emitting X radiation following orbital electron capture, or of undergoing spontaneous fission; *radioactive decay.*

REM: A special unit of dose equivalent [Roentgen Equivalent Man]. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, the distribution factor, and any other necessary modifying factors. (1 millirem = 0.001 rem)

REMEDIAL ACTION: Defined by CERCLA, Section 101 (24), as “those actions taken...in the event of a release or threatened release of hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment. ” Can include isolation, treatment, disposal, or removal actions.

REPOSITORY: A term generally applied to a facility for the disposal of radioactive wastes, particularly high-level waste and spent fuel.

ROENTGEN: The special unit of exposure. One Roentgen equals 2.58 x 10^{-4} Coulomb per kilogram of air. The international unit of X radiation or gamma radiation that is the amount of radiation producing, under ideal conditions in one cubic centimeter of air at O “C and 760 mm Hg pressure, ionization of either sign equal to one electrostatic unit of charge.

RUNOFF: Any water, leachate, or liquid which flows overland from onsite to offsite or that portion of precipitation which flows overland.

SEISMIC: Of, pertaining to, of the nature of, subject to, or caused by an earthquake.

SHALL: Denotes a requirement.

SHALL CONSIDER: Requires that an objective assessment be performed to determine to what extent the specific factor, criterion, guideline, standard, etc., will be incorporated into or satisfied by the referenced action or design. The results and basis of this assessment shall be documented. Such documentation shall be retrievable and can be in the form of engineering studies, meeting minutes, reports, internal memoranda, etc.

SITE CLOSURE AND STABILIZATION: Those actions that are taken upon completion of operations that prepare the disposal site for custodial care and that assure that the disposal site will remain stable and will not need ongoing active maintenance.

SUBSIDENCE: Sinking or depression of the ground surface; generally due to loss of subsurface support.

SURVEILLANCE: Observation of the disposal site for purposes of visual detection of need for maintenance, custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.

TECTONIC: Of or pertaining to the deformation of the earth's crust, the forces involved in or producing such deformations, and the resulting rock structures and external forms.

TRANSMISSIVITY: A basic geohydrological property of an aquifer; the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under unit hydraulic gradient; calculated as the product of the effective permeability times the effective thickness of the aquifer.

TRANSURANIC (TRU) WASTE: Waste that is contaminated with alpha-emitting radionuclides of atomic number greater than 92 and half-lives greater than 20 years in concentrations greater that 100 nanoCuries per gram (nCi/g), or has a smearable alpha contamination greater than 4,000 dpm/cm^2 averaged over the accessible surface.

TREATMENT: Any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste nonhazardous or less hazardous; safer to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

UNSATURATED ZONE: The zone of soil or rock between the ground surface and the water table; also termed the vadose zone.

VADOSE ZONE: The zone of soil or rock between ground surface and the top of the groundwater that contains water disseminated through the pore volumes at pressures less than atmospheric pressure and that will thus not flow freely into wells penetrating the zone.

VALIDATION: For the purposes of environmental investigations, refers to a systematic process of reviewing a body of data against a set of criteria to assure that the data are acceptable for their intended use.

VAULT: An artificial enclosed volume covered by an overhead structure; especially a passage or room used for storage or safekeeping.

VERIFICATION: For the purposes of environmental investigations, refers to a systematic process of determining whether procedures, processes, data, or documentation conform to specified requirements.

VULCANISM: The processes by which magma (molten rock material within the earth) and its associated gases rise into the earth's crust and are extruded onto the earth's surface and into the atmosphere.

WATER TABLE: The surface within an unconfined aquifer between the zone where water freely flows and the vadose zone; that surface of a body of unconfined groundwater at which the pressure is equal to atmospheric pressure. Effectively, the elevation of the water at equilibrium inside a piezometer penetrating an unconfined aquifer.

X-RADIATION; X-RAY: Electromagnetic waves resulting from high energy orbital electrons dropping to a lower energy state; may be spontaneously emitted by some isotopes but is artificially produced by high energy electrons impinging on a metal target.

Appendix C
Bibliography of Regulatory Documents

CFR	**Code of Federal Regulations** Superintendent of Documents Government Printing Office Washington, DC 20402
10 CFR 20:	Standards for Protection Against Radiation
10 CFR 60:	Disposal of High-Level Radioactive Wastes in Geologic Repositories, Licensing Procedures
10 CFR 61:	Licensing Requirements for Land Disposal of Radioactive Wastes
10 CFR 71:	Transport of Radioactive Wastes
10 CFR 1022:	Compliance with Floodplains/ Wetlands Environmental Review Requirements
29 CFR 1910:	Safety and Health Regulations for Workers Engaged in Hazardous Waste Operations
29 CFR 1919:	Occupational Safety and Health Standards
29 CFR 1926:	Safety and Health Regulations for Construction
40 CFR 61:	National Emission Standard for Radionuclide Emissions from Department of Energy Facilities
40 CFR 122:	Permitting Requirements for Land Disposal Facilities
40 CFR 125	Criteria and Standards for the NPDES (National Pollutant Discharge Elimination System)
40 CFR 141:	National Primary Drinking Water Regulations
40 CFR 142:	National Interim Drinking Water Regulations
40 CFR 191:	Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High Level, and Transuranic Radioactive Wastes
40 CFR 192:	Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings
40 CFR 240:	Guidelines for the Thermal Processing of Solid Wastes
40 CFR 241:	Guidelines for the Land Disposal of Solid Wastes
40 CFR 249:	Guideline for the Federal Procurement of Cement and Concrete Containing Fly Ash
40 CFR 256:	EPA Guideline for State Solid Waste Management Plans
40 CFR 260:	Hazardous Waste Management System: General
40 CFR 261:	Hazardous Waste Management System: Identification and Listing of Hazardous Wastes
40 CFR 262:	Standards for Generators of Hazardous Wastes
40 CFR 263:	Standards for Transporters of Hazardous Wastes
40 CFR 264:	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265:	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 267:	Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities
40 CFR 268:	Land Disposal Restrictions

40 CFR 270:	EPA Administered Permit Programs: The Hazardous Waste Permit Program
40 CFR 271:	Requirements for Authorization of State Hazardous Waste Programs
40 CFR 280:	Underground Storage Tanks
40 CFR 300:	National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (also known as National Priorities List for CERCLA)
41 CFR 101:	Federal Property Management Regulations
48 CFR 10:	Federal Acquisition Regulations
49 CFR 170:	Transportation
49 CFR 171-179:	Transportation of Radioactive Waste

CONGRESSIONAL ACTS	Superintendent of Documents Government Printing Office Washington, DC 20402

Clean Air Act
Public Law 88-206
42 U. S. C. 1857

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
Public Law 96-510
42 U. S. C. 9601-9662

Superfund Amendments and Reauthorization Act of 1986
(SARA, amending CERCLA)
Public Law 99-499

Clean Water Restoration Act
Public Law 89-753
43 u. s. c. 431

Federal Water Pollution Control Act
Public Law 86-70
33 u. s. c. 1157

National Environmental Policy Act (NEPA)
Public Law 91-190
42 U. S. C. 4321

Resource Conservation and Recovery Act (RCRA)
Public Law 94-580
42 U. S. C. 6901-6991K

Hazardous and Solid Waste Amendments of 1984
(HSWA)
(amending RCRA)
Public Law 98-616

Safe Drinking Water Act
Public Law 93-523
42 U. S. C. 201

Toxic Substances Control Act
Public Law 94-469
15 U. S. C. 2601

Water Quality Act
Public Law 89-234
33 U.S.C. 1151

National Low Level Radioactive Waste Policy Act of 1980
Public Law 96-573
42 U. S. C. 2021-2121D

Low Level Radioactive Waste Policy Act Amendments Act of 1985
Public Law 99-240
Atomic Energy Act of 1954 (and amendments)
42 U. S. C. 2011-2296

Energy Reorganization Act of 1974

DOE	**U.S. Department of Energy** 1000 Independence Avenue, SW Washington, DC 20585
Order 5280.2A	Low-Level Radioactive Waste Management Policy
Order 5400.3	Hazardous and Mixed Waste Management Policy

Order Series 5480, including:

	Requirements for Radiation Protection
	Contractor Occupational Medical Program Requirements
	General Environmental Protection Program Requirements
	Radiation Protection of the Public and the Environment
	Hazardous and Radioactive Mixed Waste Management
	Radiological Effluent Monitoring and Environmental Surveillance
Order 5480.lB	Environmental, Safety, and Health Program for DOE Operations
Order 5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes
Order 5480.4	Environmental Protection, Safety, and Health Protection Standards
Order 5480.5	Safety of Nuclear Facilities
Order 5481.lB	Safety Analysis and Review System (SARS)
Order 5500.1A	Emergency Management System
Order 5500.3	Reactor and Nonreactor Nuclear Facility Emergency Planning, Preparedness, and Response Program for DOE Operations
Order 5633.2	Control and Accountability of Nuclear Materials: Responsibilities and Authorities
Order 5633.3	Control and Accountability of Nuclear Materials
Order 5633.4	Nuclear Materials Transactions: Documentation and Reporting
Order 5700.6B	Quality Assurance
Order 5820.2A	Radioactive Waste Management
Order 6430.1A	General Design Criteria
EXECUTIVE ORDERS	National Archives and Records Administration 8th Street and Pennsylvania Avenue, NW Washington, DC 20408
Order 11988	Floodplain Management
Order 11990	Protection of Wetlands
Order 12088	Federal Compliance with Pollution Control Standards
FR	**Federal Register** Superintendent of Documents U.S. Government Printing Office 710 North Capitol Street, NW Washington DC 20402
45 FR 12746	Preliminary Notification of Hazardous Waste Activity
48 FR 3	Standards for Remedial Actions at Inactive Uranium Processing Sites
50 FR 28	Decommissioning Criteria for Nuclear Facilities
54 FR 20694	DOE Guidelines for Compliance with the National Environmental Policy Act
AR	**Army Regulation** Headquarters Department of the Army Washington, DC 20310
AR 40-14	Medical Services Control and Recording Procedures for Exposure to Ionizing Radiation and Radioactive Materials

AR 200-1	Environmental Protection and Enhancement
AR 200-2	Environmental Effects of Army Actions
AR 385-11	Ionizing Radiation Protection
ER	**Engineer Regulation** Headquarters U.S. Army Corps of Engineers 20 Massachusetts Avenue, N. W. Washington, DC 20314-1000
ER 385-1-80	Ionizing Radiation Protection
ER 385-1-92	Safety and Occupational Health Document Requirements for Hazardous Waste Site Remedial Actions
ER 1110-1-263	Chemical Data Quality Management for Hazardous Waste Remedial Activities
ER 1180-1-6	Construction Quality Management
EM	**Engineer Manual** Headquarters U.S. Army Corps of Engineers 20 Massachusetts Avenue, N. W. Washington, DC 20314-1000
EM 385-1-1	Safety and Health Requirements
EM 385-1-80	Radiation Protection Manual
EM 1110-2-505	Guidelines for Preliminary Selection of Remedial Action for Hazardous Waste Sites
EM 1110-1-4000	Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites

Appendix D
Department of the Army Low-Level Radioactive Waste (LLRW) and Mixed Waste (MW) Disposal and Remediation Policy

a. In 1985, Congress enacted the Low-Level Radioactive Waste (LLRW) Policy Amendments Act. This Act requires states to dispose of their own LLRW, and urged formation of compacts with neighboring states to consolidate the number of facilities for the disposal of compact-wide LLRW. Certain states formed nine compacts for LLRW disposal. Other states remain unaffiliated. To date, only two compacts have operating LLRW disposal facilities and no new facilities are foreseen within the next few years or more. In 1991, Envirocare, Inc., a private company in Utah, opened a facility that can dispose of limited concentrations of certain radioactive wastes and even some mixed wastes. Projects that have or will have a probability of discovering or generating LLRW need to be carefully evaluated to determine if suitable waste disposal facilities may be available. It should be noted that a disposal facility may not be available and the only options may be temporary storage or not to remove the material from the site.

b. On 3 September 1992, the Department of Army (DA) was officially designated as the Department of Defense (DoD) Executive Agent for managing disposal of DoD LLRW. The DA delegated this responsibility to the U.S. Army Armament, Munitions, and Chemical Command (AMCCOM) along with certain other responsibilities. See attached Headquarters, U.S. Army Corps of Engineers (HQUSACE) policy memorandums for additional information and specific authorities. The DoD Executive Agent is to assure that DoD components' LLRW disposal practices are in compliance with constantly changing regulatory and license requirements, and to ensure the components' awareness of all available disposal options.

c. The Hazardous, Toxic, and Radioactive Waste Mandatory Center of Expertise (HTRW-MCX) has been designated to provide radioactive technical support to assist the USACE Districts working on radioactive projects. This support is available during all phases of a project from initial investigation through transportation and disposal. All USACE elements are required to notify and coordinate with HTRW-MCX all radioactive work and activities (LLRW or mixed waste (MW)) being done for DoD or for others. Timely notification and cooperation between the USACE Districts and the HTRW-MCX will help the HTRW-MCX achieve its delegated responsibility for the proper management and disposal of LLRW and MW. See attached " USACE Project Report" form. The USACE HTRW-MCX will perform USCE-wide coordination for HQUSACE and with the DoD executive agent for projects that are DoD funded. USACE Districts must coordinate all LLRW and MW disposal actions to ensure that appropriate disposal is accomplished and that appropriate records are maintained and reported. All LLRW disposal actions funded by DoD are to be approved by the DoD Executive Agent (see attached "Request for LLRW/MW Generated or Waste Disposal" form.

d. It is requested that the following information (see attached forms) be provided to the HTRW-MCX, ATTN: CENWO-HX-S, 12565 West Center Road, Omaha, NE 68144-3869, Fax 402-697-2613.

(1) USACE project report. The attached USACE project report form and information should be provided as soon as a project is identified to have a potential for waste or unwanted radioactive items that disposal. This information will be maintained by the HTRW-MCX so that assistance can be provided when determining disposal options.

(2) Disposal plan. Because of the complexity with LLRW/MW disposal or storage related to Compact, state, NRC, and Federal requirements, it is highly recommended that a disposal plan be developed as early as possible. The disposal plan is a report with specific project information that describes the type of material and proposed methods for disposal of LLRW or MW. The attached outline is recommended information required as a minimum for management decisions and technical support. If this information is unavailable, it could be included in a scope of work or other documents that will be generated for the project for use in making decisions as to treatment, disposal, packaging, transportation, and budget. This is not to be all-inclusive but is intended to generate questions as to the project technical needs and management requirements.

(3) Request for LLRW/MW for disposal. The attached "Request for LLRW/MW for Disposal" form and information are required to be provided as soon as a determination for disposal has been made and prior to any shipment. It is recommended that the information be provided to the HTRW-MCX for review and concurrence at least 3 weeks before shipment for all projects. For DoD-funded projects only, this information will then be forwarded by the HTRW-MCX to the DoD Executive Agent for coordination and approval.

USACE Project Report
on
Current/Proposed Low Level Radioactive Waste (LLRW) / Mixed Waste (MW)
Generation/Remediation Activities

DESIGN DISTRICT : ______________________________

EXECUTING DISTRICT : ______________________________

USACE POC : ______________________________

PHONE # : ______________ FAX #, ______________

PROGRAM/FUNDING-IRP,FUDS, SUPERFUND, ETC. .: ______________

PROJECT NAME/ID NUMBER: ______________________________

STATUS/PHASE : ______________________________

INSTALLATION NAME: ______________________________

INSTALLATION POC: ______________________________

PHONE #: ______________ FAX #: ______________

SITE NAME: ______________________________

STATE: ______________ COMPACT: ______________

SCOPE OF WORK: ______________________________

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RADIONUCLIDES OF CONCERN: ______________ CONCENTRATIONS : ______________
Please attach any additional information that is available or if additional space needed:

VOLUME OF RAD WASTE IN CU FT: ______________________________

MIXED WASTE PRESENT? Y/N : ______________ PROFILED YET? Y/N : ______________

DESCRIPTION OF WASTE/PROFILE: ______________________________

Send or Fax to HTRW-MCX, ATTN: CENWO-HX-S, 12565 West Center Road, Omaha NE 68144-3869
Fax 402-697-2613. For POC and additional information see the HTRW Center of Expertise Specialists.

Recommended Disposal Plan/Report Outline

The following is recommended information that as a minimum would be required for decisions on disposal, storage, or treatment. This information could be included in a scope of work or other documents that will be generated for the project that would be used to make decisions as to treatment, disposal, storage, packaging, transportation, and budget. This is not to bean-inclusive, but is to generate questions as to the project technical needs and management requirements. For POC and additional information, see the HTRW Center of Expertise Specialists.

1. Installation name

2. Project name

3. Proposed methods to profile or classify waste. Type of project RCRA, CERCLA, or other.

4. Description of site to be remediated and/or material(s) being proposed for disposal. This would include any information on what the material(s) was used for, historical information, type of site (manufacturing, maintenance, disposal, etc.) , and if the material(s) was under any NRC or other type of license. If information is not known or is unavailable, please explain procedures proposed to gather such information.

5. Estimated volume of material(s), radionuclides, and concentrations. Description of mixed waste if any. If information is not known or is unavailable, please explain procedures proposed to gather such information.

6. Proposed method of disposal or treatment. If information is not known or is unavailable, please explain procedures to arrive at proposed methods.

7. Proposed method(s) of packaging and transportation.

8. Special requirements relating to Compacts, Federal, State, or local regulations or procedures.

Request for Low-Level Radioactive Waste (LLRW)/Mixed Waste (MW) Generated for Disposal

Send or Fax to HTRW-CX, ATTN: CENWO-HX-S, 12565 West Center Road, Omaha NE 68144-3869
Fax 402-697-2613. For additional information or POC see the HTRW Center of Expertise Specialists.

PROJECT NAME:____

SITE NAME:____

REQUESTING POC:____
PHONE #:__________________________ FAX #:__________________________

INSTALLATION NAME:____
INSTALLATION POC:____
PHONE #:__________________________ FAX #:__________________________

ORIGINATING STATE:____________ COMPACT:________________________
COMPACT NOTIFIED: Y/N COMPACT POC:________________________________

DISPOSAL FACILITY:____
____

DISPOSAL POC:____
PHONE #:__________________________ FAX #:__________________________

TRANSPORTATION METHOD:____
TRANSPORT POC:____
PHONE #:__________________________ FAX #:__________________________

TYPE OF CONTAINERS:____________________ #OF CONTAINERS:_________________
____________________ ____________________
____________________ ____________________
____________________ ____________________

RADIONUCLIDES OF CONCERN:________________ CONCENTRATIONS:______________
________________ ______________
________________ ______________
________________ ______________

TOTAL VOLUME OR RAD WASTE IN CU FT:____
MIXED WASTE PRESENT? Y /N:_________ PROFILED YET? Y /N:__________

DESCRIPTION OF WASTE/PROFILE (Attach waste analyses if available): ____
____
____

Within 10 working days the following information will be completed by the DoD Executive Agent and returned to the Requesting POC with copy furnished to HTRW-CX

APPROVED:________ APPROVED WITH COMMENT:________ DISAPPROVED:________

COMMENT/DISAPPROVAL REASONS

____

____

____

SIGNATURE/DATE:____

Figure D-1 is an image of a memorandum from C. McMillan, OASD, to OASA (I,L&E), et al., dated September 3, 1992, designating the Army as the DoD Executive Agent for managing DoD's LLRW. Figure D-2 is an image of a memorandum from L. D. Walker, OASA (I,L&E), to DACS-SF, dated September 18, 1992, transmitting that designation to AMCCOM for implementation. Figure D-3 is an image of a memorandum from S. W. Goodman, DUSD (ES), to OASA (I,L&E), et al., dated January 10, 1994, incorporating the Executive Agent authority of DA into a DoD instruction and specifying the Naval Nuclear Propulsion Program is not within the Executive Agent's responsibility. Figure D-4 is an image of a memorandum from L. D. Walker, OASD, to DACS-SF dated August 17, 1994, transmitting the Executive Agent authority to AMCCOM and further detailing the LLRW disposal requirements. Figure D-5 is an image of a memorandum from C. Jones, CEMP-RT, to all Commanders of Major Subordinate Commands (MSCs) dated October 5, 1994, describing USACE policy concerning the responsibilities of AMCCOM and HTRW-MCX.

September 3, 1992

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY, (INSTALLATIONS, LOGISTICS, AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY, (INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE, (MANPOWER, RESERVE AFFAIRS, INSTALLATIONS AND ENVIRONMENT)
DIRECTOR, DEFENSE LOGISTICS AGENCY

SUBJECT: DoD Low-Level Radioactive Waste (LLRW) Disposal Policy

The Department of the Army has been unofficially functioning as the DoD Agent for LLRW disposal through Interservice Support Agreements (ISSA) with the DoD Components. This memorandum officially designates the Army as the DoD Executive Agent for managing disposal of DoD's LLRW. This does not apply to the LLRW managed by the Naval Nuclear Propulsion Program under the authority of Executive Order 12344 and Public Law 98-525 (42 USC 7158).

The attached guidance outlines responsibilities and procedures under this designation. Costs incurred by the Army in providing these services are to be funded through ISSAs or agreements between the Army and Army customers. Each Component generating LLRW is responsible for instituting and maintaining waste minimization efforts. This policy will be incorporated in a comprehensive DoD Instruction scheduled for coordination later this year.

Attachment

Colin McMillan

Figure D-1. Memo designating DoD executive agent (Continued)

RESPONSIBILITIES AND PROCEDURES

1. The Department of the Army will provide LLRW disposal services, including contract development and administration, for use by DoD Components. Details of these services and any additional DoD specific relationships will be embodied in interservice support agreements (ISSAs) or memoranda of agreements with DoD Components generating LLRW.

2. All procedural matters arising in the disposal of LLRW will be referred to Commander, U.S. Army AMCCM, ATTN: AMSMC-SFR, Rock Island, IL 61299-6000. A working group, composed of members from each Component, will be established. This Component working group will meet periodically to review procedural issues. Components may refer policy issues to the Defense Environmental Policy Council (DEPC) for action. The DEPC may constitute, as appropriate, a committee to develop solutions.

3. Costs incurred by the Department of the Army in providing these services are to be funded through ISSAs or agreements between the AMCCOM and DoD customers using established procedures.

4. The Department of the Army will provide the following additional capabilities:

a. Provide technical assistance and information related to the operation of the DoD LLRW disposal program.

b. Develop and maintain procedures for packaging, transportation and disposal of LLRW.

c. Maintain an inventory of wastes disposed of, and any other information required by State, State Compacts and Federal regulatory authorities.

d. Maintain ongoing liaison with all State, State Compacts and Federal regulators. Advise DoD Components, as required, of new laws, regulations and requirements.

e. Develop and maintain a central file on State and Federal requirements for packaging, transportation and disposal of LLRW.

f. Establish and maintain an ongoing LLRW volume-reduction program and stay abreast of state of the art developments in LLRW minimization technology.

Figure D-l. (Concluded)

MEMORANDUM THRU DIRECTOR OF THE ARMY STAFF

FOR ARMY SAFETY OFFICE (DACS-SF)

SUBJECT : Department of Defense Low-Level Radioactive Waste (LLRW) Disposal Policy

Attached is the official designation of the Army as the Executive Agent for the disposal of LLRW for the Department of Defense. Also attached are the responsibilities and procedures for the implementation of this designation.

Request this designation be officially transmitted through appropriate command channels to the U.S. Army Armament, Munitions and Chemical Command for implementation. Further request an implementation plan including a schedule of rates to be charged for their services be developed within 120 days of receipt of this designation.

A component working group will be formed to assist in the development of a rate schedule and to establish detailed procedural instructions which will be used by each of the customers in order to request and receive services by the Army.

All costs incurred by the Army in providing these services are to be funded through Interservice Support Agreements. It is imperative that these agreements be developed and signed as soon as possible to ensure that continued service is provided to all customers. Failure to implement may lead to legal and pecuniary liability for commanders in the field.

Request you acknowledge receipt of this memorandum. My point of contact is Lieutenant Colonel Randall Morin at (703) 697-0440.

Lewis D. Walker
Deputy Assistant Secretary of the Army
(Environmental, Safety and Occupational Health)
OASA (I,L&E)

Attachments

Figure D-2. Memorandum transmitting executive agent status to AMCCOM

DUSD (ES)/PP

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY
(INSTALLATIONS, LOGISTICS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY
(INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE
(MANPOWER, RESERVE AFFAIRS, INSTALLATIONS AND ENVIRONMENT)
DIRECTOR, DEFENSE LOGISTICS AGENCY (D)

SUBJECT : Department of Defense Low-Level Radioactive Waste (LLRW) Disposal Policy

The Department of the Army was appointed the Department of Defense (DOD) Executive Agent for the management of the disposal of LLRW for the Department by Assistant Secretary of Defense (Production and Logistics (ASD (P&L) memorandum of September 3, 1992. This policy was never incorporated into a DoD Instruction as indicated in the memorandum. Therefore, this memorandum officially continues the policy originally established by the ASD (P&L) memorandum and adds some supplemental responsibilities for the Executive Agency. This does not apply to the LLRW managed by the Naval Nuclear Propulsion Program under Authority of Executive Order 12344, Naval Nuclear Propulsion Program, and Public Law 98-525 (42 USC 7158).

As Executive Agent for the managing disposal of DOD's LLRW, the Department of the Army is assigned the supplemental responsibilities:

providing disposal services on a cost-reimbursable basis for the DoD components
maintaining central inventory of all LLRW disposed of and through the DoD program
fostering relationships with licensing agencies and compacts on behalf of the DoD LLRW program
providing guidance to installations for managing, storing and disposing of LLRW
maintaining a current compilation of federal and state LLRW disposal requirements and
providing a report to the Deputy Under Secretary of Defense (Environmental Security) within 90 days after the close of each fiscal year on the status of DoD's LLRW program, with a copy furnished to each DoD component.

Figure D-3. Memorandum affirming executive agent status (Continued)

All radioactive waste disposed of by a DoD component shall be coordinated with and approved by the DoD Executive Agent.

Sherri Wasserman Goodman
Deputy Under Secretary of Defense
(Environmental Security)

DASA (E, S&OR)
DASN (E&S)
DASAY (E, S&OM)
DLA- CAAE
DATM-ED-PP (BG Brown)
N45 (RADM Walker)
MC/LFL (BGen Reinke)
AE/CE (BGen McCarthy)
DNA
NSA

Figure D-3. (Concluded)

MEMORANDUM THRU THE DIRECTOR OF THE ARMY STAFF

FOR DIRECTOR OF ARMY SAFETY (DACS-87)

SUBJECT : Department of Army Low Level Radioactive Waste (LLRW) Disposal and Remediation Policy

The Department of the Army (DA) was appointed by the Assistant Secretary of Defense for Production and Logistics by the Executive Agent to manage the disposal of LLRW generated by activities of the military departments and defense agencies of the Department of Defense (DoD) Attch. 1) . Supplemental responsibilities were issued by the Deputy Under Secretary of Defense for Environmental Security (Attch. 2) .

The U.S. Army Material Command (AMC) should continue to conduct this mission for the Army in its role as the Executive Agent. AMC will meet the following disposal requirements:

- provide LLRW disposal services on a cost-reimbursable basis for the DoD components
- maintain central inventory of all LLRW disposed of through the DoD program
- foster relationships with licensing agencies and compacts on behalf of the DoD LLRW programs
- provide guidance to installations for management, storage and disposal of LLRW
- maintain records necessary to demonstrate that all DoD LLRW is disposed of properly
- maintain a current compilation of federal and state LLRW disposal requirements
- report to the Deputy Under Secretary of Defense (Environmental Security) within 90 days after the close of each fiscal year the status of DoD's LLRW programs, with a copy furnished to each DoD component .

Disposal of all low level radioactive water generated by a DoD component shall be coordinated with and, with limited prior exceptions related to environmental restoration activities, approved by the DoD Executive Agent. The above DoD requirements apply only to DoD component funded projects.

The U.S. Army Corps of Engineers (USACE) should continue to execute their current mission with regard to hazardous, toxic and radioactive waste remediation and installation support to the Defense Environmental Restoration Program (DERP) and the Realignment and Closure Program. Installation commanders, however, may determine the appropriate contractual mechanisms to manage and dispose of LLRW generated as a result of or incident to Resource Conservation and Recovery Act corrective actions and DRRP remediation activities. Commanders may utilize LLRW disposal mechanisms available within the USACE or AMC, or other mechanisms as appropriate, to ensure the accomplishment of uninterrupted expeditious remediations. The agency executing the remediation is responsible to coordinate all LLRW disposal actions with AMC to ensure appropriate disposal is accomplished and that appropriate records are maintained and reported for all DoD LLRW disposal actions.

This policy memorandum was developed after considerable discussion and staffing with the affected parties. Request appropriate action be taken to

Figure D-4. Memorandum defining AMC requirement pertaining to LLRW/MW (Continued) ensure that the information contained in this memorandum is incorporated into implementing regulations and other appropriate documents. Affected parties throughout the DoD should be made aware of this information. The point of contact in my office for this action is Mr. Rick Newsome. He can be reached at (703) 614-9531.

Lewis D. Walker
Deputy Assistant Secretary of the Army
(Environment, Safety and Occupational Health

Attachments

Figure D-4. (Concluded)

CEMP - RT

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT : Department of Army Low Level Radioactive Waste (LLRW) Disposal and Remediation Policy

1. Reference:

a. Memorandum, Office of the Assistant Secretary of Army, Installations, Logistics and Environment, Aug. 17, 1994, SAB (Encl 1) .

b. Memorandum, Office of the Under Secretary of Defense, 10 January 1994, Subject: Department of Defense Low Level Radioactive Waste (LLRW) Disposal Policy (Encl 2) .

c. Memorandum, Assistant Secretary of Defense, September 3, 1994, Subject: DoD Low Level Radioactive Water (LLRW) Disposal Policy (Encl 3) .

2. On 3 September 1992, the Department of Army (DA) was officially designated as the DOD Executive Agent for managing disposal of DOD's LLRW. The DA delegated this responsibility to the U.S. Army Armament, Munitions and Chemical Command (AMCCOM) , which is also assigned certain other responsibilities identified in references la thru lc.

3. The DOD Executive Agent is to assure that DOD Components' LLRW disposal practices are in compliance with constantly changing regulatory and license requirements, and to ensure the Components' awareness of all available disposal options.

4. By reference la, the Army set policy differentiating between disposal and reporting activities, and cleanup execution activities. The U.S. Army Corps of Engineers (USACE) should continue to execute its current missions as before, utilizing contract mechanisms which USACE determines are appropriate. The USACE must coordinate all LLRW disposal actions with AMCCOM to ensure appropriate disposal is accomplished and that appropriate records are maintained and reported. All USACE elements must coordinate and report all LLRW potential projects and activities to the USACE HTRW-MCX, ATTN: CEMRD - ET-H, Omaha, NE 68144-3869. The USACE HTRW-MCX will perform USACE-wide coordination with AMCCOM.

5. In addition, Installation Commanders (IC) may determine the appropriate execution agent and attendant contractual mechanism. ICs may utilize USACE, AMC , or others as appropriate.

6. Disposal of military funded LLRW must be coordinated with, and have approval of, the DOD Executive Agent, to ensure appropriate disposal is accomplished and related records are maintained and reported.

7. Request immediate implementation of the new DA policy in ref la. To facilitate this implementation, request the following actions be pursued:

Figure D-5. Memorandum to MSRs describing roles of USACE, AMCCOM, and HTRW-MCX pertaining to LLRW/MW (Sheet 1of3)

CEMP - RT
SUBJECT : Department of Army Low Level Radioactive Waste (LLRW) Disposal and Remediation Policy

USACE districts are requested to submit to the USACE HTRW-MCS a report using the enclosed form (Encl 4) , identifying current military and nonmilitary funded projects involving LLRW. This report is to be submitted by 1 November 1994.

b. All Scopes of work or Disposal Plans that require or describe disposal of LLRW shall be submitted to the HTRW-MCX for technical review. This review process is to assure that all requirements are being addressed and to provide guidance on disposal options. These documents need to be submitted as early in the planning stage as possible, to assure that a disposal mechanism is available and to avoid delays in the project.

c. All requests for coordination with DOD Executive Agent shall be routed through the HTRW-MCX, after Scopes of Work or Disposal Plans have been reviewed. The HTRW-MCX will provide assistance in coordination with DOD Executive Agent. Additional information will be provided to the Districts by the HTRW-MCX as it becomes available from the DOD Executive Agent.

d. The HTRW-MCX will keep an inventory of all military and non-military projects requiring disposal of LLRW and may request additional information as to the type and volumes of waste requiring disposal, and the proposed disposal or storage facility.

e. Through an existing Inter-Service Support Agreement (ISSA) with AMCCOM, the Corps can request disposal related services from AMCCOM, however, all such requests must be directed through the USACE HTRW-MCX.

Figure D-5. (Sheet 2 of 3)

CEMP - RT
SUBJECT : Department of Army Low Level Radioactive Waste (LLRW) Disposal and Remediation Policy

8. For further information, contact Mr. Bob Curnyn, CEMRD-ET-HT, (402) 221-7388, or Dr. Reuben Sawdaye, CEMP-RT, at (202) 272-8881.

FOR THE DIRECTOR OF MILITARY PROGRAMS:

4 Encls

CARY JONES
Chief, Environmental Restoration Division
Directorate of Military Programs

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C/F: HTRW-MCX (Mr. Joe Grasso)
ASA(I,L&E)-ESOH
HQDA, DAIM-ED-R
AMCCOM (AMSMC-RW)
CESO-I (Mr. Stout)

Figure D-5. (Sheet 3 of 3)